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MINUTES OF PROCEEDINGS

OF

The Engineering Association

OF

NEW SOUTH WALES,

ESTABLISHED 1870, INCORPORATED 1884;

ALSO,

ACT OF INCORPORATION, RULES AND BY-LAWS,

AND

LIST OF MEMBERS.

VOL. V.

EDITED BY

HENRY V. AHRBECKER, M. I. Mech. E.,

HON. SEC. ENG. ASSOC. OF N.S.W.

SYDNEY:

Published by the Association,

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1890.

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ADVERTISEMENT.

The Association, as a body, is not responsible for the facts and opinions advanced in the following pages.

Sydney: Printed by Turner & Henderson, Hunter Street.

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CONTENTS.

	Page.
Act of Incorporation	vii.
Rules and By-Laws	xiii.
Appendix containing Forms referred to in the By-Laws... ...	xxi.
List of Members	xxv.
List of Donations to the Library	xxx.

MINUTES OF PROCEEDINGS.

Annual Meeting, 10th October, 1889	xxxiii.
List of Original Communications, Session 1889-90	xxxv.
Account of Receipts and Expenditure	xxxix.
Balance Sheet	xl.
Election of Officers, Session 1889-90	xli.
General Meeting, March 20th, 1890	xliii.
,, ,, April 10th ,, ...	xliv.
,, ,, May 8th ,, ...	xlv.
,, ,, May 15th ,, ...	xlvi.
,, ,, June 12th ,, ...	xlvi.
,, ,, July 10th ,, ...	xlvii.
,, ,, July 17th ,, ...	xlviii.
,, ,, August 14th ,, ...	xlviii.
,, ,, September 11th, 1890	xlix.

PAPERS.

20th March, 1890.

Address by the President : A. D. Nelson 1

10th October, 1889.

"The Epicyclic Grab Dredger," by H. Davies 12

10th April, 1890.

"The Prevention of Damage to River Banks by Flood Waters, and the Regulation of River Channels," by W. Seymour Wells ... 22

Discussion on "Prevention of Damage to River Banks" 28

687261

8th May, 1890.

PAGE.
"Van Rysselberghe's Hydro-Dynamo System of Electric Lighting" ... 30
Discussion on "Electric Lighting" 46

12th June, 1890.

"Electric Traction," by G. Fischer 77
Discussion on "Electric Traction" 95
"Sanitary Engineering and Public Health," by J. M. Smail 118
Discussion on "Sanitary Engineering and Public Health" 134

14th August, 1890.

"Delta Metal: Its History, Properties and Uses," by Walter Reeks ... 146
Discussion on "Delta Metal" 158

11th September, 1890.

"Dangers Arising from the Use of Certain Clays in Embankments" by Angus Mackay 159
Discussion on "Dangers Arising from the Use of Certain Clays in Embankments" 173
Index 179
List of Illustrations 184

ERRATA.

Page 7, bottom line, for "Comany's," read "Company's."
„ 39, line 14 from bottom, for "Rysselburghe," read "Rysselberghe."
„ 55, „ 1 „ top, for "85," read "8.5."
„ 55, „ 2 „ „ „ "85," „ "~~85~~." ·85
„ 58, „ 2 „ „ „ "horse power hours," read "lamp hours."
„ 66, „ 13 „ „ „ "Behring," read "Behringer."
„ 66, „ 7 „ bottom for „ „ „
„ 87, „ 16 „ „ „ "Spragueomotor," read "Sprague motor"
„ 167, bottom line, for "oxodized," read "oxidized."

8th May, 1890.

PAGE.
"Van Rysselberghe's Hydro-Dynamo System of Electric Lighting"... 30
Discussion on "Electric Lighting" 46

10th June, 1890.

ACT OF INCORPORATION.

THE ENGINEERING ASSOCIATION OF NEW SOUTH WALES INCORPORATION.

An Act to Incorporate a Society called the "Engineering Association of New South Wales." [19th August, 1884.]

Preamble.

WHEREAS a Society called the "ENGINEERING ASSOCIATION OF NEW SOUTH WALES" had under certain rules and by-laws been formed at Sydney in the Colony in New South Wales for the general advancement of Engineering and Mechanical Science. And whereas the Council of the said Society is at the present time composed of the following office bearers and members Owen Blacket Consulting Engineer President Henry Selfe Government Engineer Surveyor Vice-President John Sands Mechanical Engineer Honorary Treasurer John Parry Honorary Librarian William Eugene Hort Nicolle Secretary and John Trevor Jones City Engineer Adrien Charles Mountain City Surveyor Walter Shellshear Assoc. M. Inst. C.E. Henry Davies Civil Engineer Max Thomson Civil Engineer and Robert Pollock Mechanical Engineer Members of the Council And whereas it is expedient that the said Society should be incorporated and should be invested with the powers and authorities hereinafter contained Be it therefore enacted by the Queen's Most Excellent Majesty by and with the advice and consent of the Legislative Council and Legislative Assembly of New South Wales in Parliament assembled and by the authority of the same as follows:—

Interpretation Clause.

1. For the purposes of this Act the following words in inverted commas shall unless the context otherwise indicate bear the meaning set against them respectively—

"Corporation"—The Society hereby incorporated.

"Council"—The members of the Council at any duly convened meeting thereof at which a quorum according to the by-laws at the time being shall be present.

"Secretary"—Such person or either one of such persons who shall for the time being be the Secretary or Secretaries honorary or otherwise of the said Society (saving and excepting any Assistant Secretary of the said Society).

Incorporation Clause.

2. The President Vice-President Officers and Members of the said Society for the time being and all persons who shall in manner provided by the rules and by-laws for the time being of the said Society become members thereof shall be for the purposes hereinafter mentioned a body corporate by the name or style of the "Engineering Association of New South Wales" and by that name shall and may have perpetual succession and a common seal and shall and may enter into contracts sue and be sued plead and be impleaded answer and be answered to defend and be defended in all Courts and places whatsoever and may prefer lay and prosecute any indictment information and prosecution against any person whomsoever and any summons or other writ and any notice or other proceeding which it may be requisite to serve upon the Corporation may be served upon the Secretary or one of the Secretaries as the case may be or if there be no Secretary or if the Secretaries or Secretary be absent from the Colony then upon the President or Vice-President.

Rules and By-laws.

3. The present rules and by-laws of the said Society shall be deemed and considered to be and shall be the rules and by-laws of the said Corporation save and except in so far as any of them are or shall or may be altered varied or repealed under the powers for that purpose therein contained or are or may be inconsistent or incompatible with or repugnant to any of the provisions of this Act or any of the laws now or hereafter to be in force in the said Colony.

Power to hold and deal with lands.

4. The Corporation shall have power to purchase acquire and hold lands and any interest therein and also to sell and dispose of the said lands or any interest therein and all lands tenements hereditaments and other property of whatever nature now belonging to the said Society under the said rules and by-laws or vested in Trustees for them shall on the passing of this Act be vested in and become the property of the said Corporation subject to all charges and claims and demands in anywise affecting the same.

Property vested in Corporation.

Ordinary business to be managed by the Council.

5. The ordinary business of the Corporation in reference to its property shall be managed by the Council and it shall not be lawful for individual members to interfere in any way in the management of the affairs of the Corporation except as by the rules and by-laws for the time being shall be specially provided.

Powers of Council.

6. The Council shall have the general management and superintendence of the affairs of the Corporation and excepting the appointment of Presidents and Vice-Presidents and other honorary officers who shall be appointed as the By-laws of the Society shall from time to time provide the Council shall have the appointment of all officers and servants required for carrying out the purposes of the Society and of preserving its property and it may also define the duties and fix the salaries of all officers Provided that if a vacancy should occur in the Council during any current year of the Society's proceedings it shall be lawful for the Council to elect a member of the Society to fill such vacancy for the unexpired portion of the then current year. The Council may also purchase or rent land houses or offices and erect buildings or other structures for any of the purposes for which the Society is hereby incorporated and may borrow money for the purposes of the Corporation on mortgages of the real and chattel property of the Corporation or any part thereof or may borrow money without security provided that the amount so borrowed without security shall never exceed in the aggregate the amount of the income of the Corporation for the last preceding year and the Council may also settle and agree to the covenants powers and authorities to be contained in the securities aforesaid.

Liability of Members.

7. In the event of the funds and property of the Corporation being insufficient to meet its engagements each member thereof shall in addition to his subscription for the then current year be liable to contribute a sum equal thereto towards the payment of such engagements but shall not be otherwise individually liable for the same and no member who shall have commuted his annual subscription shall be so liable for any amount beyond that of one year's subscription.

Custody and use of Common Seal.

8. The Council shall have the custody of the common seal of the Corporation and have power to use the same in the affairs and business of the Corporation and for the execution of any of the securities aforesaid and may under such seal authorise any person without such seal to execute any deed or deeds and do such other matter as may be required to be done on behalf of the Corporation but it shall not be necessary to use the said seal in respect to the ordinary business of the Corporation nor for the appointment of their Secretaries Solicitor or other officers.

Copy of By-laws to be evidence.

9. The production of a printed or written copy of the rules and by-laws of the Corporation certified in writing by the Secretary or one of the Secretaries as the case may be to be a true copy and having the common seal of the Corporation affixed thereto shall be

conclusive evidence in all Courts of such rules and by-laws and of the same having been made under the authority of this Act.

Elections not made in due time may be made subsequently.

10. In case of any of the elections directed by the rules and by-laws for the time being of the Corporation to be made shall not be made at the times required it shall nevertheless be competent to the Council or to the members as the case may be to make such elections respectively at any ordinary meeting of the Council or at any annual or special general meeting held subsequently.

President, Vice-President, or Secretary may represent Corporation for certain purposes.

11. The President or Vice-President or the Secretary or either one of the Secretaries may represent the Corporation in all legal and equitable proceedings and may for and on behalf of the Corporation make such affidavits and do such acts and sign such documents as are or may be required to be done by the plaintiff or complainant or defendant respectively in any proceeding to which the Corporation may be parties.

12. This Act may be cited as the "Engineering Association Incorporation Act of 1884."

RULES AND BY-LAWS.

RULES AND BY-LAWS.

Section I.

OBJECTS.

The Engineering Association of New South Wales was first established, and has since been incorporated by Act of Parliament, for the general advancement of Engineering and Mechanical Science, and more particularly those branches of Civil and Mechanical Engineering which tend to develop the resources of Australia, and to receive and discuss at its stated meetings original papers on Civil and Mechanical Engineering.

Section II.

CONSTITUTION.

1. The Engineering Association of New South Wales shall consist of Members who are entitled to the privileges of Corporate Membership, also Honorary Members, Associates and Students, who are not entitled to the privileges of Corporate Membership.

2. Every Candidate for election into the class of Member shall be more than twenty-one years of age, and must be actually engaged in some branch of Engineering, and must be considered by the Council to be qualified for election.

3. Associates to be gentlemen not under twenty-four years of age, who from their scientific attainments or position in society may be considered eligible for election by the Council.

4. Honorary Members shall be persons who have been eminent benefactors to this or some other of the Australian Colonies, and distinguished patrons and promoters of Engineering and

Manufacturing industries. Honorary members shall be exempted from payment of fees and contributions; they may attend the meetings of the Association, and they shall be furnished with copies of the publications of the Association, but they shall have no right to hold office, to vote, or otherwise interfere in the business of the Association. The number of Honorary Members shall not at any one time exceed twenty, and not more than two Honorary Members shall be elected in any one year.

5. Students shall be persons not under sixteen years of age who are students in Engineering at a University, or who are apprenticed or articled to any branch of Engineering, and may afterwards be admitted as Members at the discretion of the Council. Such persons may continue Students until they attain the age of twenty-two years, but not longer.

6. The Officers of the Association shall be a President, Vice-President, Secretary, Honorary Secretary, Honorary Treasurer, and six other Members of Council, being eleven persons, who shall constitute the Council to direct and manage the concerns of the Association; also two Auditors of Accounts, and a Librarian. Such officers shall be elected or appointed annually in manner hereinafter directed.

Section III.

ELECTION AND EXPULSION OF MEMBERS, ASSOCIATES, HONORARY MEMBERS, AND STUDENTS.

1. Any person desirous of being elected a Member, Associate, or Student, must be proposed and recommended according to Form No. 1. All recommendations for admission to be signed by not less than five members if the application be for admission as a Member or Associate, and by three members if it be for a Student.

2. The proposal so made being delivered to the Secretary, shall be submitted to the Council, who, on approving the qualifications of the candidate, shall present the application for ballot.

3. The elections to take place by ballot. All recommendations for admission to go to the ballot unless unanimously rejected

by the Council. The approved ballot list to be signed by the President, and copies forwarded to the members. Elections to take place at the ordinary General Meetings.

4. The proportion of votes for deciding the election of any candidate shall be at least four-fifths of the number voting, twenty members at least to record their votes.

5. Any person duly elected a Member, Associate, or Student, shall be informed thereof without delay, by a letter, according to Form No. 2, enclosing a promise (Form No. 3) to abide by the Act of Incorporation, Rules and By-laws of the Association, which promise the person elected must sign and return to the Secretary, and he must pay the admission fee and subscription for the current half-year within two months after the date of his election, which otherwise shall become void, but the Council may, in particular cases, extend the time.

6. Every person proposed as an Honorary Member must be recommended by the Council and elected by ballot.

7. A majority of members present at any Ordinary Meeting shall have the power to expel an obnoxious member from the Association, provided that a resolution to that effect has been moved and seconded at the previous Ordinary Meeting, and that due notice of the same has been sent in writing to the Member in question within a week after the meeting at which such resolution has been brought forward. The vote to be taken by ballot.

Section IV.

ELECTION OF COUNCIL AND OFFICERS.

1. The President, Vice-President, Honorary Treasurer, Honorary Secretary, and the six other Members of Council, shall be elected annually by ballot, at the Annual General Meeting to be called in October.

2. The Secretary and Librarian shall be appointed annually by the Council at their first Meeting after Annual General Meeting.

3. Any vacancies occurring in the Council during the year may be filled up by the Council.

4. It shall be the duty of the Council each year to prepare a list containing the names of Members whom they recommend for

election, to the respective offices of President, Vice-President, Honorary Treasurer, and Honorary Secretary, together with the names of six other Members whom they recommend for election as ordinary Members of Council. The names thus recommended shall be proposed at one meeting of the Council, and agreed to at a subsequent meeting. Such list shall be suspended in the Association's Room, and a copy shall be sent to each ordinary Member not less than seven days before the day appointed for the Annual General Meeting.

5. Each Member present at the Annual General Meeting shall have the power to alter the list of names recommended by the Council, by adding to it the names of any eligible Members not already included in it and removing from it an equivalent number of names, and he shall use this list, with or without such alterations, as a balloting list at the election of Officers and Council.

6. No ballot for the election of Members of Council or of Officers shall be valid unless twenty members at least shall record their votes.

7. Two Auditors shall be appointed at the Ordinary General Meeting in August or September, who shall audit the accounts and lay them before the Annual General Meeting in October.

Section V.

CONTRIBUTIONS TO THE FUNDS.

1. Each Member shall pay two guineas, and each Associate two guineas, and each Student one half-guinea per annum.

2. Every new Member or Associate shall pay an admission fee of two guineas, and every student shall pay an admission fee of one guinea.

3. All Subscriptions to be payable half-yearly in advance, in the months of April and October.

4. Any Member or Associate whose Subscription is not in arrears, may pay the amount of ten annual payments at any time as a life composition for the annual payments.

5. Members or Associates whose Subscriptions are twelve months in arrears, will not be entitled to any of the privileges of the Association. The name of any Member or Associate who shall be two years in arrears with his Subscriptions shall be erased from the list of Members and Associates; but such Member may be re-admitted on giving a satisfactory explanation to the Council, and on payment of arrears.

6. Every individual elected a Member, Associate, or Student, shall be liable for the payment of his Annual Subscriptions, until he has signified to the Secretary, in writing, his desire to resign, having previously paid all arrears, or until he has forfeited his right to remain in, or to be attached to the Association.

Section VI.

THE PRESIDENT.

1. The President shall take the chair at all Meetings of the Association, the Council, and the Committees, at which he is present, and shall regulate and keep order in the proceedings.

2. In the absence of the President, it shall be the duty of the Vice-President to take the chair.

3. In the absence of both the President and Vice President, the meeting may elect any Member of Council, or in case of their absence, any Member present to take the chair at the meeting.

Section VII.

THE COUNCIL.

1. The Council to be elected according to the provisions of Section IV. shall consist of the President, Vice-President, Honorary Treasurer, Secretary, Honorary Secretary, and six other Members of Council.

2. The direction and management of the concerns of the Association are vested in the Council, under the control of the Act of Incorporation, Rules, and By-Laws.

3. The Council shall meet as often as the business of the Association may require; and at every meeting three shall constitute a quorum. The Council may appoint Committees, for special purposes, to report to the Council.

4. The Council shall draw up a yearly Report on the state of the Association, which shall be read at the Annual General Meeting.

5. The Funds of the Association shall be lodged at a bank approved of by the Association. Claims against the Association, when approved by the Council, shall be paid by the Treasurer. All payments to be made by cheques, signed by the Treasurer, and countersigned by the Secretary.

Section VIII.

THE SECRETARIES.

It shall be the duties of the Secretaries, under the direction of the Council, to conduct the correspondence of the Association; to attend all meetings of the Association, and of the Council, and of Committees; to take minutes of the proceedings of such Meetings, and all communications that may be ordered to be read; to superintend the publication of such papers as the Council may direct; to have charge of the Library; to direct the collection of the Subscriptions, and the preparation of the account of the expenditure of the funds, and to present all accounts to the Council for inspection and approval.

Section IX.

MEETINGS.

1. The Ordinary General Meetings of the Association shall be held on the second Thursday of each month, from March to September (inclusive) in each year, subject to alteration by the Council with due notice.

2. At the Ordinary General Meetings the business shall be transacted in the following order, unless the Chairman specially decide otherwise:—

(1) The Minutes of the preceding meeting to be read, and after having been confirmed, to be signed by the Chairman.

(2) Business arising out of the Minutes to be entered on.

(3) Communications from the Council to be brought forward.

(4) Ballot for the election of new Members.

(5) New Members to enrol their names and be introduced.

(6) Donations to be laid on the table and acknowledged.

(7) Papers to be read and discussed.

3. Every Member shall have the privilege of introducing one stranger, to be present at the Ordinary Meetings of the Association, on writing his name in a book provided for that purpose.

4. The Annual General Meeting of the Association shall be held on the second Thursday in October, at eight o'clock in the evening, to receive and deliberate upon the Report of the Council with the Annual Statement of the Accounts, and to elect the Council and Officers for the ensuing year.

5. The Council may, at any time, call a Special General Meeting of Corporate Members for a specific purpose relative to the direction and management of the concerns of the Association; and the Council are at all times bound to do so on a requisition in writing of twelve Corporate Members, specifying the nature of the business to be transacted.

6. A notice shall be sent to the Corporate Members at least seven days before the time appointed by the Council for such Special General Meeting, and the notice shall specify the nature of the business to be transacted, and no other than that business shall be transacted at that meeting, and twenty shall constitute a quorum.

Section X.

ENACTMENT OF RULES AND BY-LAWS.

No new Rule, or By-Law, or alteration or repeal of existing Rules or By-Laws, shall be made, unless carried at two successive General Meetings, at each of which twenty members, at least, must be present.

Section XI.

PAPERS AND ORIGINAL COMMUNICATIONS.

1. All Papers and Original Communications must be forwarded to the Secretary, who will lay them before the Council; and if approved, notice will be given, and the papers read and discussed.

2. Any subject connected with engineering may be brought forward for discussion before the Association, provided the Member bringing the matter forward has first asked for and obtained the sanction of the Council.

Section XII.

THE PROPERTY OF THE ASSOCIATION.

1. The property and effects of the Association, of what kind soever, are vested in the Corporate Members for the time being for the use of the body politic and corporate solely in furtherance of the public and scientific objects contemplated in the Act of Incorporation.

2. Every Paper, Map, Plan, Drawing, or Model, presented to the Association shall be considered the property thereof, unless there shall have been some previous arrangement to the contrary, and the Council may publish the same in any way and at any time they may think proper.

3. The Library shall be open for consultation and for the issue and return of books, subject to such regulations as the Council may deem necessary.

APPENDIX TO THE BY-LAWS.

Form No. 1.

THE ENGINEERING ASSOCIATION OF NEW SOUTH WALES.

Nomination Paper.

Name in full

Designation or Occupation

Business Address

being of the required age, and desirous of admission into the Engineering Association of New South Wales, we, the undersigned, from our personal knowledge propose and recommend him as a proper person to become a thereof. (Member, Associate, or Student to be inserted by proposer.)

Witness our hands this day of 18

PROPOSED BY }
SECONDED BY } Five Members' Signatures are required for Member or Associate, and Three for a Student.

Signature of Candidate.

Form No. 2.

THE ENGINEERING ASSOCIATION OF NEW SOUTH WALES.

(Established 1870. *Incorporated* 1884.)

Sir, Sydney, 18

I have the honor to inform you that you have this day been elected a of the Engineering Association of New South Wales, and I beg to forward to you a copy of the Act of Incorporation, Rules and By-Laws of the Association.

According to the Rules of the Association you are required as to pay being your admission fee and subscription for the current half-year, and to return the accompanying obligation with your signature within two months of the date of your election, otherwise your election will be void. These conditions being complied with, you will be considered as admitted into the Association, when any publications or notices to which you are entitled will be forwarded according to your directions.

I beg to direct your attention to section V. of the By-Laws, and to point out that all half-yearly subscriptions become due in the months of April and October in each half-year for the half-year then commencing.

I have, &c,

Secretary.

Form No. 3.

THE ENGINEERING ASSOCIATION OF NEW SOUTH WALES.

I, the undersigned, being elected

of the Engineering Association of New South Wales, do hereby promise that I will be governed by the Act of Incorporation of the Association, and by the Rules and By-Laws of the said Association, as they are now formed or as they may hereafter be altered, amended, or enlarged, under the powers of the said Act; and I promise to promote the objects of the said Association as far as shall be in my power, and to attend the meetings thereof as often as I conveniently can. Providing that whenever I shall signify in writing to the Secretary for the time being, that I am desirous of withdrawing my name therefrom, I shall (after the payment of any arrears which may be due by me at that period) be free from this obligation.

Witness my hand, this day of 18

Form No. 4.

THE ENGINEERING ASSOCIATION OF NEW SOUTH WALES.

Sydney, 18

Sir,

I am directed by the Council of the Engineering Association of New South Wales to inform you that your subscription to the Association is two years in arrears, and in pursuance of Article 5, Section V., of the Rules and By-Laws, the Council have declared by special vote on the day of 18 , that you have forfeited your claim in future to belong to the Association, and your name will be in consequence expunged from the register, unless payment is made previous to

But notwithstanding such forfeiture as regards the future, I am directed to call upon you for payment of your arrears, amounting to £

I am, Sir, &c.,

Form No. 5.

Balloting List for the Election of the Officers and Council.

THE ENGINEERING ASSOCIATION OF NEW SOUTH WALES.

Date

BALLOTING LIST for the Election of the Officers and Council.

Present Council.	Names proposed as Members of New Council.	Names proposed by any dissentient Member.
President.	President.	President.
Vice-President.	Vice-President.	Vice-President.
Hon. Treasurer.	Hon. Treasurer.	Hon. Treasurer.
Hon. Secretary.	Hon. Secretary.	Hon. Secretary.
Members of Council.	Members of Council.	Members of Council.

If you wish to substitute any other name in place of that proposed, erase the printed name in the second column, and write opposite to it, in the third, that which you wish to substitute.

LIST OF MEMBERS.

NOVEMBER, 1889.

CORPORATE MEMBERS.

1886	Adams, W. J.	71 Clarence-street, Sydney
1888	Ahrbecker, H. V....	Morts Dock and Engineering Works, Balmain
1883	Auldjo, L. C.... ...	Mort's Dock and Engineering Works, Balmain
1889	Blackwell, L. B. ...	
1878	Bennett, F. ...	*Evening News* Office, Sydney
1873	Blacket, O.	Technical College
1876	Boulton, G.	Mort's Dock and Engineering Works, Balmain
1885	Briggs, S.	Mort's Dock and Engineering Works, Balmain
1888	Brown, T.	North Shore Ferry Co., Sydney
1884	Bush, T. F.	Australian Gaslight Co., Sydney
1887	Cameron, C. G. ...	118 Pitt Street, Sydney
1887	Campbell, R. B. ...	care of Imray & Co., Kent-street, Sydney
1888	Cardew, J. H. ...	Victoria Chambers, Elizabeth-street, Sydney
1887	Christie, A.	88 Pitt-street
1888	Clarke, G.	
1880	Cracknell, E. W....	Bond-street, Sydney
1878	Crispin, W.	66 Harbour-street, Sydney
1870	Cruickshank, W. D.	Marine Board Offices, Sydney.
1883	Darley, C. W. ...	Harbours and Rivers Department, Sydney
1873	Davies, H.	Harbours and Rivers Department, Sydney
1883	Diamond, P.	52 Pitt-street, Redfern
1886	Dickinson, H. E. ...	H.R.N.S.N. Co., Sussex-street, Sydney
1889	Drake, F. M.	care of A. A. Gallagher & Co., P.O. Chambers, Pitt-street
1886	Duncan, A. J.... ...	72 Elizabeth-street, Sydney
1883	Dunn, J. M.	Tattersall's Chambers, Hunter-street, Sydney
1883	Elder, J.	"Rocky Glen," Balmain
1885	Farmer, W. T. ...	Sydney Chambers, 130 Pitt-street, Sydney
1882	Fenwick, J.	Balmain

1870	Ferguson, T. ...	Mort's Dock and Engineering Works, Balmain
1882	Finlayson, R. W. ...	H. P. Gregory & Co., Pitt-street, Sydney
1882	Fischer, G. ...	Existing Lines Department, Sydney
1885	Fitzmaurice, J. S. ...	97 Clarence-street, Sydney
1888	Foote, J.	Balmain Steam Ferry Co., Balmain
1870	Franki, J. P.	Mort's Dock and Engineering Works, Balmain
1886	Frost, H. P.	587 George-street, Sydney
1885	German, J.	7 Cohen's Buildings, Spring-street, Sydney
1888	German, W. H. ...	Colonial Sugar Refining Co., 5 O'Connell-street, Sydney.
1882	Goodall, E.	Paul-street, Balmain
1883	Grant, J.	3 Point-street, Pyrmont
1885	Grant, J. L.	Harris-street, Pyrmont
1883	Griffin, J. G.	Australian Club, Sydney
1885	Greenwood, W. ...	"Gracombe," Croydon
1875	Hargrave, L.	Rushcutter's Bay-road, Sydney
1888	Haycroft, J. J. ...	Council Chambers, Woollahra
1883	Henderson, J. B. ...	Water Supply Department, Brisbane
1883	Henson, J. B.	City Engineer's Office, Town Hall, Sydney
1873	Howe, H. B.	Tramway Works, Randwick
1883	Hudson, H.	Clyde Engineering Works, Granville
1870	Hunter, P.	Newcastle S.S. Co., Lime-street, Sydney
1889	Hutchinson, T. W.	3 Ballast Point Road, Balmain
1877	Irons, T.	Atlas Engineering Works, Woolwich
1882	Jones, J. Trevor ...	City Engineer, Town Hall, Sydney
1885	Kendall, R	Existing Lines Department, Sydney
1883	Kerle, H. W.	141 Pitt-street, Sydney
1885	Key, G. A....	88 Pitt-street, Sydney
1884	Kidd, H.	Colonial Sugar Refining Company, Sydney
1881	Kopsch, ...	"Saxonia," Boulevarde, Petersham
1870	Laing, J.	Snail's Bay, Balmain
1885	Leahey, J. A. L. ...	263 George-street, Sydney
1883	Mackay, A. ...	Technical College, Sydney
1885	Macdonald, A. B. ...	care of W. Howard Smith & Sons, Melbourne
1877	McCredie, A.	20 Wynyard-street, Sydney
1882	McCredif, G.	20 Wynyard-street, Sydney

1887	McKinney, H. G. ...	Athenæum Club, Sydney
1887	McKechnie, C. ...	Change Alley, Sydney
1881	McPherson, H. ...	491 Kent-street, Sydney
1876	Mainwaring, M. ...	Austral Foundry, Pyrmont
1886	Marshall, A. D. ...	Marine Board Office, Sydney
1885	Massey, G.	Foy's Chambers, Bond-street, Sydney
1889	Mestayer, R. L. ...	Webb's Avenue, Ashfield
1883	Milne, W.	Sussex-street, Sydney
1879	Moore, F....	Existing Lines Department, Sydney
1888	Morland, J. O. ...	Gas Works, St. Leonards
1881	Morse, R....	Rockdale
1877	Nelson, A. D.... ...	Hay-street, Darling Harbour, Sydney
1888	Newton, W. M. ...	Elizabeth-street, Sydney
1875	Nicolle, W. E. H....	Harbours and Rivers Department, Sydney
1886	Noakes, W. M. ...	43 York-street, Sydney
1886	Paisley, W.	Burwood
1885	Parkinson, W. A. ...	"Arthursleigh," William-street, Randwick
1882	Parrott, T. S.... ...	Mercantile Chambers, Pitt-street, Sydney
1881	Parry, J.	Existing Lines Department, Sydney
1878	Patterson, J. J. ...	Brumby-street, Strawberry Hills, Sydney
1873	Perdriau, H.	Balmain Engineering Works, Balmain
1878	Pollock, R. ...	Bulli Coal Co., Bridge-street, Sydney
1870	Poolman, S.	Colonial Sugar Refining Co., 5 O'Connell-street, Sydney
1873	Proctor, J.	19 George-street, Redfern
1886	Reeks, W....	139 Pitt-street, Sydney
1884	Richmond, J.	care of J. See & Co., Sussex-street, Sydney
1888	Row, T.	Colonial Architect's Office, Sydney
1888	Rudolph, T. H. ...	Sewerage Office, Bathurst-street, Sydney
1873	Sands, J.	Albion Engineering Works, Pyrmont
1878	Sands, H. G.	Albion Engineering Works, Pyrmont
1870	Scott, W....	Government Railway Works, Redfern
1873	Scott, R.	Government Railway Works, Redfern
1885	Scott, T.	Orient S.S. Co.
1870	Selfe, N	Lloyd's Chambers, George-street, Sydney
1885	Shaw, P. W.	Existing Lines Department, Sydney
1881	Shellshear, W. ...	Existing Lines Department, Sydney
1889	Sinclair, R.	81 Pitt-street, Sydney

1884	Smail, J. M.	Sewerage Department, Sydney
1878	Smith, H. Shaw ...	17 Pitt-street, Sydney
1884	Stables, E. C.... ...	New Zealand Sugar Co., Auckland
1882	Stewart, T.	Electric Telegraph Department, General Post Office, Sydney
1883	Stone, J. J.	Harbours and Rivers Department, Sydney
1887	Storer, J.	163 Clarence-street, Sydney
1886	Strachan, G.	care of D. & W. Robertson, Sydney
1885	Thompson, J. R. ...	Atlas Engineering Works, Woolwich
1883	Touch, J. E.	care of Booth, McDonald & Co., Christchurch, New Zealand
1882	Tulloch, R.	Crown-road, Pyrmont
1886	Vale, H. J.	Locomotive Works, Auburn
1883	Van de Velde C. ...	Royle's Chambers, Bond-street, Sydney
1888	Wade, L. A. B., ...	Sewerage Department, Sydney
1883	Walsh, F.	76 Elizabeth-street, Sydney
1882	Walker, J.	H.M.C.S. "Wolverene"
1887	Walker, P. B.... ...	Electric Telegraph Department, General Post Office, Sydney
1884	Warren, W. H. ...	Sydney University
1886	Watkins, C. E. ...	Reefton, New Zealand
1883	Waugh, D.	Brisbane-street, Sydney
1885	Wells, W. S.	Bell's Chambers, 129 Pitt-street, Sydney
1882	West, W.	Balmain Engineering Works, Balmain
1878	Wildridge, J.	81 Pitt-street, Sydney
1886	Wilkinson, C. S. ...	Department of Mines, Sydney
1878	Wilson, W. G. ...	Snail's Bay, Balmain
1881	Wright, J.	Westmoreland-street, Glebe

HONORARY MEMBERS.

Barnet, J.	Colonial Architect
Broderick, H.	Sydney Club
Cracknell, E. C.	Superintendent Electric Telegraph Department, G.P.O.
Jacob, A. H.	Ashfield
Moriarty, E. O....	Engineer-in-Chief, Harbours and Rivers Department
Poole, W. T.	Hampden House, Pitt-street, Redfern

ASSOCIATE MEMBERS.

1886	Carson, J. F.	Ashfield
1886	Hordern, S.	Haymarket, Sydney
1888	Sands, R.	374 George-street, Sydney
1889	Summerbell, T. ...	North Shore Ferry Company

STUDENTS.

1884	Burrows, C.	Albion Engineering Works, Pyrmont
1888	Brown, S.	Albion Engineering Works, Pyrmont
1886	Cape, F. W.	Mort's Dock and Engineering Works, Balmain
1888	Dibbs, J. A.	Eveleigh Railway Workshops, Eveleigh
1886	Edgell, R. G.	Eveleigh Railway Workshops, Eveleigh
1887	Finch, E. W.	care of H. W. Kerle, 141 Pitt Street, Sydney
1887	Ferrier, R. R. ...	Lansdowne-street, Surry Hills
1888	Hinde, A. W. T. ...	"Tallooma," Edgecliff Road, Waverley
1882	Laidley, R.	W. Laidley and Co., Exchange, Sydney
1887	McNab, F. C.	Tramway Works, Randwick
1887	Owen, P. T.	Cabbage Tree, Wollongong
1887	Poole, W., Junr. ...	Hampden House, Pitt-street, Redfern
1888	Robinson, H. E. ...	Manchester House, William-street, Sydney
1883	Stokes, S....	Drayton House, Leichhardt
1883	Woolnough, H. B. ...	Mort's Dock and Engineering Works, Balmain
1888	Wilkinson, E. H. ...	Water and Sewerage Board

DONATIONS TO THE LIBRARY

OF THE

ENGINEERING ASSOCIATION OF NEW SOUTH WALES.

List for the Year Ending September 30th, 1890.

"Engineering."

Indian Engineering, vol. 4, Nos. 10 to 26 and index; vol. 5; vol. 6, Nos. 1 to 6.

Bulletin de la Société Vaudoise des Ingenieurs et des Architectés, Nos. 5 to 8, 1888; Nos. 1 to 4, 1889; Plate 23.

Proceedings of the Royal Colonial Institute, vol. 19.

Atti del Collegis degli Ingegneri e degli Architetti, Anno XI., 1888.

Institution of Mechanical Engineers, May, July, October, 1888. January, 1889.

Transactions of the American Society of Civil Engineers, February, May to August, October to December, 1888. February to April, 1889. Indices to vols. 18 and 19, 1888.

Proceedings, January, July, November, and index for 1888. January, February, and March, 1889.

Transactions of the North of England Institute of Mining and Mechanical Engineers; vol. 37, Parts 5, 6, list of members, and index; vol. 38, Parts, 1, 2.

Proceedings of the Royal Technical Test Laboratory of Berlin. 1888, 6th year, Part 4. 1889, Tests of stone, Appendix II.

Transactions of the Institution ot Engineers and Ship-builders in Scotland, vol. 31.

Royal Society of Canada, vols. 1 to 5.

Transactions of the American Institute of Mining. Engineers vol. 16.

Meteorological Report, 1885. New Zealand.

The Evolution of the Flying Machine (photographs).

Principles of Mechanics. Goodeve.

On Gas Engines.

A Manual of Mechanics.

The Elements of Mechanism.

Text-book on the Steam Engine, and on Gas Engines. Goodeve.

Phormium Tenax as a fibrous plant. Hector.

Useful Plants of Australia. Maiden.

Transactions and Proceedings of the New Zealand Institute, 1888. Vol. 21.

Journal and Proceedings of the Royal Society of New South Wales. Vol. 22, Part 2.

Report of Geological Explorations during 1887-8. No. 19. New Zealand.

Twenty-third Annual Report on the Colonial Museum and Laboratory, with List of Donations and deposits during 1887-8. New Zealand.

Calendar of the University of Sydney. 1889.

The Steamship. Vol. 1, No. 1. July, 1889.

Diagrams and Plans. Royal Commission. Conservation of Water. Third and Final Report of the Commissioners.

THE ENGINEERING ASSOCIATION

OF

NEW SOUTH WALES.

(Established, 1870. *Incorporated, 1884.)*

SESSION 1889-90.

PART I.

MINUTES OF PROCEEDINGS,

ANNUAL GENERAL MEETING,

10th October, 1889.

Mr. A. D. NELSON, President, in the Chair.

The following candidate was balloted for and duly elected as

MEMBER:

J. W. ROCK.

Annual Report and Balance Sheet.—The President read the Annual Report of the Council, and Balance Sheet for the year ending September, 1889, as follows:—

"Your Council, in presenting to you the 19th Annual Report for the year ending September 30th, 1889, feel it incumbent upon them to make some remarks upon the transactions of the past year,

for although they have no hesitation in saying that they, as a professional body, hold their position, and still retain all the prestige which is due to an organisation of the kind, yet they must admit there has been a considerable reduction in the number of members—a circumstance they are extremely sorry to have to report—caused by the great depression which has existed, for some time past in the engineering community, many of the workshops being almost idle; the draughtsmen and consulting engineers have been unable to obtain employment, and those in business to keep up the staff usually employed, hence they have had to sever their connection with us to find fresh fields and pastures new in other colonies. The retrenchment scheme carried out by the Government recently has also had a tendency to decrease their numbers; men who have been for years employed by the Government have been dismissed, causing them to have to encounter difficulties which prevented their names remaining on the books. Then again, the action of the Council, they being compelled to strike off the books those members who have neglected to pay their subscriptions, has considerably decreased the roll; and last of all, the busy hand of death has removed some of their oldest members from their midst. They regret to say the first President of this Association, Mr. J. Fyfe, is one of that number. Those who knew him best, they are sure, will agree with them when they say his career was an honourable one, and that his history should act as a stimulus to those who are left behind. He was a man honoured and respected, who had the courage of his convictions, and was always to the front in matters he believed to be right. They regret also to have to record the deaths of The Hon. J. Sutherland, Mr. W. Grant and Mr. W. C. Bennett, who were identified with the Association, rendered valuable assistance to it, and helped it forward as much as lay in their power so to do; and your Council are sure it requires no words to induce you to think more kindly, more respectfully or more honourably of these members who have joined the great majority. Suffice it to say, they respected them in life, and honour them in death. The total number of members of all classes whose names now remain on the books is 153.

"Referring to the financial position of the Association, the statements show the income has been more than the expenditure for the past year. While congratulating themselves that they have had ample funds to meet all demands, it will be seen that there is not a great surplus; but they are satisfied that every member will be pleased that the income more than covers the expenditure.

"Your Council very much regret having to place on record the carelessness and irregularity of a large number of members in paying their subscriptions. A glance at the outstanding subscriptions will show they have members amongst them who are either careless as to the future of the Association or are of an exceedingly mercenary nature. They are sure the members will give the Council the consideration they are entitled to in this matter, as the liabilities must be met, and the only means of accomplishing this is by receiving the subscriptions as they become due, this being the only source of revenue. They therefore earnestly hope members in arrears will pay more attention to the notices of the Secretary in future, so as to keep the finances in a healthy condition.

"The lease of the present rooms expired in August last. The Council deemed it advisable to remain, as they are in every respect suitable; therefore they have moved in the matter for the purpose of obtaining a further lease, and it is satisfactory to know there is every probability of obtaining this.

"The summary of business transacted during the last twelve months is as follows:—They have had 14 meetings with an average attendance of 35; the papers have been very interesting and have recorded much valuable information. The list of papers read and subjects discussed are as follows:—

"In October, 1888, a discussion on Mr. J. B. Henson's paper on the proposed 'Western Suburbs Sewerage Scheme.'

"In December, President's Opening Address, and the adjourned discussion on Mr. Henson's paper as above.

"In January, 1889, on the 'Modern Tendency of Railway Practice,' by Mr. W. Shellshear; also a paper by Mr. J. B. Henson, on the 'Hawkesbury and Nepean Alluvial Deposits and Irrigation.'

"In February, on the 'Pumping Machinery of the Water Supply of Sydney, and Irrigation,' by Mr. Norman Selfe.

In March, on 'Coating Iron and Steel with Copper,' by Dr. Florance.

"In April, on 'Sanitary Improvements,' by Mr. E. W. Cracknell.

"In May, 'Remarks on Some New South Wales Timbers,' by Mr. J. H. Maiden; also a paper by Mr. G. A. Key, on 'Don's Patent Smoke Consumer and Fuel Economiser.'

"In June, on 'Tests of New South Wales Timbers,' by Professor W. H. Warren, and discussion on Mr. J. H. Maiden's paper.

"In June, Adjourned Meeting. Discussion on Mr. G. A. Key's paper.

"In July, on 'Flour Mill Machinery,' by Mr. A. D. Nelson.

"In August, on 'Extracting Gold and Silver from Pyrites by a New Wet Process,' by Dr. Storer.

"In August, at a Special General Meeting, on 'Water Gas,' by Mr. J. W. Rock.

"In September, on the 'Operations of Power Companies and Power Transmission by Compressed Air,' by Mr. Norman Selfe.

"In September, Adjourned Meeting. Discussion on Mr. N. Selfe's paper.

"At the April Meeting, a letter from the Institute of Engineers and Ship-builders of Scotland was submitted, stating that Society had resolved to take the initiation in raising a suitable Memorial to the late Professor McQuorn Rankine, and asking, amongst other kindred Societies, this Association's consideration and support. The matter was referred to the Council to deal with, who fully recognised its importance, and voted the sum of £10 10s. to so worthy an object.

"At the same meeting a motion was submitted by Mr. W. D. Cruickshank to sanction the limitation of the Association's Session

to eight months in lieu of twelve, the vacation to embrace the four hottest months of the year, viz.: November, December, January, and February. This arrangement was unanimously approved of and adopted.

"At an Adjourned Meeting in June, Mr. L. Hargrave exhibited a small flying-machine, made by himself, and driven by compressed air.

"At the July Meeting it was announced that Mr. G. Fischer had resigned his office of Editor of Proceedings through pressure of business matters, and that the Council had appointed Mr. H. V. Ahrbecker to fill his place. Also that Mr. R. W. Finlayson had tendered his resignation as a Member of the Council owing to his business engagements, and the Council had appointed Mr G. Fischer to fill the vacancy.

"At the August Meeting, the death of the late Mr. John Fyfe, Senr., at the ripe old age of 86 years was announced (by the Chairman.) Mr. Fyfe was the first President of this Association, 19 years ago, and a motion was agreed to that a resumé of his professional career be recorded in the Association's Proceedings.

"On the 14th September, the Association visited the Patent Asphaltum Company's Works, at Greenwich, and were met and shown over the Works by the Manager and Directors of the Company, when a pleasant and instructive afternoon was spent.

"The Council regret that in consequence of Mr. Fischer's inability to give that amount of attention to the publication of the last year's volume of Proceedings which he had devoted to the previous volumes, and his ultimate resignation of the office of Editor, Volume III. has not yet been issued; but it is hoped that during the next few weeks this volume will have been completed by Mr. Ahrbecker, and will then be ready for issue.

"The Association's previous volumes have been issued to about forty kindred Societies in different parts of the world, and several exchanges have been the result, as per list appended, for which the Council take this opportunity of returning their thanks.

"The question of holding a Scientific and Mechanical Exhibition in connection with the Association has been suggested at one of the Council Meetings, a diversity of opinion existed, consequently no positive action was taken, the opinion of some of the Council being that it would be better to wait until the colony has recovered from the depression which has existed for some time past."

The SECRETARY then read the Balance Sheet for the year as follows :—

ENGINEERING ASSOCIATION OF NEW SOUTH WALES.

ACCOUNT OF RECEIPTS AND EXPENDITURE FOR THE YEAR ENDING 30TH SEPTEMBER, 1889.

Dr. **Receipts.**

1888.		£ s. d.	£ s. d.
Oct. 1st.	To Balance in Bank	71 4 8	
„	„ Cash in hand	1 11 11	
			72 16 7
	„ Entrance Fees—		
	6 New Members at £2 2s.		12 12 0
	„ Annual Subscriptions		240 13 0
	„ Annual Re-union, 1887		3 0 0
	„ Rent		26 0 0
	„ Excess payment by Treasurer to Bank		0 19 1
			£356 0 8

Expenditure. **Cr.**

	£ s. d.
By Rent of Rooms	72 0 0
„ Printing and Engraving Proceedings	18 18 6
„ General Printing	13 19 4
„ Periodicals	12 18 0
„ Petty Cash including Postage, Stationery, Advertising, Insurance, &c.	27 8 8
„ Secretary's Allowance	40 0 0
„ Donation to Rankine Memorial	10 10 0
„ Sundries	12 6 7
„ Excursions	5 1 7
„ Collection on Cheques, etc.	0 11 3
„ Cash at Bankers £138 3 6	
„ Cash on hand 4 3 3	
	142 6 9
	£356 0 8

Audited and found correct.

H. E. DICKINSON, JAMES ELDER, } Auditors.

ENGINEERING ASSOCIATION OF NEW SOUTH WALES.

BALANCE SHEET AS AT THE 30TH SEPTEMBER, 1889.

Dr.	£	s.	d.
To Capital of the Association at this date	1,146	8	1
	£1,146	8	1

Cr.	£	s.	d.
By Fixed Deposits in the English, Scottish, and Australian Chartered Bank	424	19	4
„ Balance Current Account	142		9
„ Annual Subscriptions in Arrear	149	2	0
„ Library, Drawings, Photos, &c.	350	0	0
„ Furniture and Fittings	80	0	0
	£1,146	8	1

Audited and found correct

H. E. DICKINSON, JAMES ELDER, } AUDITORS.

The PRESIDENT moved on behalf of the retiring Council—"That the Report and Balance Sheet, as read, be adopted," which motion was seconded by Mr. H. E. Dickinson, and unanimously agreed to by the meeting.

ANNUAL RE-UNION.—The PRESIDENT stated that it had been customary in previous years to have an annual re-union of members and friends, but that last year the matter had lapsed in consequence of a controversy as to the form it should take. He would like to see the old customs adhered to, and asked the meeting to express an opinion on the matter. Mr. G. Fischer moved, seconded by Mr. L. C. Auldjo—"That the annual re-union be held this year in the form of a picnic, the Council to effect all the necessary arrangements. The motion was agreed to.

ELECTION OF OFFICERS AND COUNCIL.—The PRESIDENT announced that the next business was the election of Officers and Council for the ensuing year. Messrs. R. Scott and H. G. Sands were called on to act as scrutineers. The ballot was then taken with the following result :—

PRESIDENT:

A. D. NELSON (*re-elected*).

VICE-PRESIDENT:

G. FISCHER.

HON. SECRETARY:

H. V. AHRBECKER.

HON. TREASURER:

JOHN SANDS (*re-elected*).

OTHER MEMBERS OF COUNCIL:

W. D. CRUICKSHANK
W. SHELLSHEAR
R. POLLOCK
J. B. HENSON
L. HARGRAVE
H. E. DICKINSON.

Paper.—Mr. Henry Davies read a paper on his "Patent Epicyclic Grab Dredge," which was fully illustrated with working models and drawings. The hour being late, Mr. G. Fischer moved, seconded by Mr. H. E. Dickinson, "the adjournment of the discussion," which was agreed to by the meeting.

MINUTES OF PROCEEDINGS.

20TH MARCH, 1890.

MR. A. D. NELSON, PRESIDENT, in the Chair.

THE following candidates were balloted for and duly elected :—

MEMBERS:

DUNCAN SALMOND
GEORGE ASHCROFT
W. A. CHETTLE
THOMAS ANDREW.

The PRESIDENT announced the election by the Council of Mr. Lawrence Hargrave as Librarian, and Mr. W. E. H. Nicolle, as Secretary.

DONATION.—The President reported that the Council had been offered some valuable original certificates of the first screw propeller trials made by the Admiralty, which had been accepted for the Association, and he thanked Mr. T. Andrews, the donor, on behalf of the Association.

ANNUAL VOLUME.—The President announced that Volume III. of the Society's Proceedings had been completed, and available for issue to members.

PRESIDENT'S ANNUAL ADDRESS.—The President then proceeded to read his Annual Address to the members, and in concluding he thanked them for the honour they had done him by re-electing him as President, and he explained that his recent illness had prevented him from dealing with many subjects mentioned in his address as fully as he otherwise would have done.

Mr. R. Pollock moved a vote of thanks to the President, which was seconded by Mr. Hargrave, and supported by Mr. W. D. Cruickshank, who took the opportunity of making some explanatory statements *re* the inspection of land boilers, alluded to in the address. The vote of thanks was unanimously accorded by the meeting, and suitably acknowledged by the President.

Vote of Thanks to the Editor.—Mr. H. E. Dickenson drew attention to Vol. III. of the Proceedings, which he considered a creditable production by the newly-appointed Editor (Mr. H. V. Ahrbecker), and he moved "that a vote of thanks be accorded to Mr. Ahrbecker for his editorial services and trouble in producing such creditable work." Mr. G. Fischer, in suitable terms, seconded the motion, which was carried by acclamation, and duly acknowledged by Mr. Ahrbecker.

10th April, 1890.

Mr. A. D. NELSON, President, in the Chair.

Proposed Mechanical Exhibition.—The President stated that a proposal had been made by the Council to consider the advisibility of holding another Exhibition, similar to those previously held under the auspices of the Asssociation, and it was decided to submit the matter to the general meeting for discussion; owing, however, to the small attendance, he would postpone the consideration of the question until the next meeting.

Departure of Mr. Hy. Broderick from Australia.—The President announced that Mr. Broderick, one of the oldest members of this Association, was on the eve of leaving Sydney for a time, and he (the President) considered the Association might mark its esteem for him by assembling on board the steamer on the day of his departure for the purpose of wishing him *bon voyage* and a safe return.

Paper on "The Prevention of Damage to River Banks by Flood-waters, and the Regulation of River Channels," by W. Seymour Wells. In the absence of Mr. Wells, who is stationed

at Mudgee, as Road Superintendent, and was unable to attend the meeting, Mr. H. E. Dickinson, Member of Council, kindly undertook to read the paper. A discussion followed, in which Messrs. Shellshear, Henson, Fischer, Dickinson, the President, and the Secretary took part.

8th May, 1890.

Mr. A. D. NELSON, President, in the Chair.

The following candidate was balloted for and duly elected :—

MEMBER:

J. W. ASHCROFT.

Proposed Mechanical Exhibition.—The President announced that the question of holding another Scientific and Mechanical Exhibition, similar to the two former ones held by this Association, had been introduced in the Council, and after consideration, it had been resolved to submit the project to the General Meeting, in order to obtain an expression of opinion and decision by the members. Mr. Norman Selfe was of opinion that the time was premature for any movement of the kind, owing to the depressed state of trade generally, and also on account of the recent disastrous floods in the country. Mr. H. Davies moved, "that the question be deferred for consideration for a period of six months." Mr. R. Pollock considered the time was unfavourable for the success of the project, and moved, "that the matter be again submitted and considered in twelve months' time." Mr. Van de Velde was in favour of dealing with the matter at once. Mr. Diamond seconded Mr. Davies' motion; and Mr. W. D. Cruickshank, after referring to the former Exhibitions, which he explained had been held with a view to strengthening the Society's financial position, seconded Mr. Pollock's motion. The amendment, "that the question be submitted and considered in twelve months' time," was put to the meeting and carried. The original motion by the Council was then put and negatived.

Paper.—Mr. C. Van de Velde read a paper on "The Van Rysselberghes' Hydro-dynamo System of Electric Lighting." The discussion was opened by Mr. G. Fischer, and followed by Messrs. Norman Selfe, Fitzmaurice, and Shellshear. The hour being late, Mr. H. E. Dickinson moved, seconded by Mr. Selfe, the adjournment until the following Thursday, which was agreed to.

15th May, 1890.

Mr. A. D. NELSON, President, in the Chair.

Discussion on Mr. Van de Velde's Paper.—The President called on Mr. H. E. Dickinson, the mover of the adjournment, to open the discussion, which was continued by Messrs. Cruickshank, Ashcroft, Fitzmaurice, Tournay-Hinde, and the President; also, by two visitors, Messrs. Webb and Callender. At the close of the discussion, Mr. Van de Velde replied to the various points raised, and stated that he hoped on a future occasion to bring the matter again before the Association, when he would be able to exhibit the apparatus.

12th June, 1890.

Mr. A. D. NELSON, President, in the Chair.

The following Candidates were balloted for and duly elected :—

MEMBERS :

C. S. CANDSELL.
J. PICKERING.
L. BENNETT.
W. H. SPEECHLEY.

Excursion to the Ryde and Chatswood Reservoirs.—The President announced that an excursion was to take place on the following Saturday, the 14th instant, to view the Reservoirs in connection with the North Sydney Water Supply Works, and expressed a hope that there would be a good attendance.

Paper.—Mr. G. Fischer read a paper on "Electric Traction." At its conclusion Mr. Callender, a visitor, exhibited specimens of the Callender type of bitumen insulated electric cables, and explained their advantages and mode of manufacture. The hour being late, Mr. H. E. Dickinson moved, seconded by Mr. J. Fitzmaurice, the adjournment of the discussion for a fortnight, which, on being put to the meeting, was carried.

10th July, 1890.

Mr. A. D. NELSON, President, in the Chair.

The following candidates were balloted for and duly elected:—

MEMBERS:

R. J. THORPE.
T. W. SEAVER.
E. S. NIXON.

STUDENT:

C. W. J. WILLIAMSON.

Discussion on Mr. G. Fischer's Paper.—The President stated that a number of views of electric motors, cars, &c., were to be shown on the screen by the aid of the lantern, illustrative of some of the remarks of the speakers. These views were then shown and described by Messrs. Fischer, Dickinson and Fitzmaurice. The President then called upon Mr. Dickinson, the mover of the adjournment, to continue the discussion in which also the following gentlemen took part:—Messrs. Fitzmaurice, Cruickshank, Nixon, Howe and Shellshear Members; and Messrs. Kingsbury and Ballou, visitors. The hour being late, Mr. Shellshear moved, seconded by Mr. Henson, that the discussion be further adjourned until the 17th instant.

The motion was agreed to, and the meeting then terminated.

17th July, 1890.

SPECIAL MEETING.

Mr. A. D. NELSON, President, in the Chair.

Adjourned Discussion on Mr. Fischer's Paper on "Electric Traction."—The President invited members to continue the discussion; but there being no response, he made a few brief remarks on the subject, and then called on Mr. Fischer to reply to the various criticisms on his paper, after which the subject was declared closed.

Paper on "Sanitary Engineering and the Public Health," by Mr. J. M. Smail. At the close of the reading of the paper, the hour being late, Mr. Trevor Jones in suitable terms proposed a vote of thanks to the author, and also moved that the discussion be adjourned until the next meeting. Messrs. Dickinson and Henson seconded the motions respectively, which were then carried. Mr. Smail, in acknowledging the vote of thanks, stated that, with the approval of the Water and Sewerage Board, he would have much pleasure in showing any of the members models of the various sanitary appliances now in use.

The meeting then terminated.

14th August, 1890.

Mr. A. D. NELSON, President, in the Chair.

Patent Fire Escape.—The President called attention to a New Fire Escape, invented by Mr. Paddle, which that gentleman had brought to the rooms to exhibit, and invited the members to examine it at the close of the meeting.

Discussion on Mr. Smail's Paper on "Sanitary Engineering and the Public Health."—The President called on Mr. Trevor Jones, the mover of the adjournment, to open the discussion in which the following gentlemen also took part: Messrs. Henson, Cracknell, and Haycroft, members, and Mr. Foxall, a visitor.

Mr. Smail having replied to the remarks on his paper, then described some models illustrating the working of the system adopted in connection with the house-drainage to the main sewers, and now being enforced by the Water and Sewerage Board. The President thanked Mr. Smail for his explanation of the models.

Launch of 600-Ton Barge.—The President announced that a 600-ton Hopper Barge was to be launched by the Atlas Engineering Co., at 8 o'clock on Saturday, and that Mr. J. R. Thompson, the manager, had invited any members interested to be present.

Paper on "Delta Metal," by Mr. Walter Reeks.—At the close of the reading of the paper, Messrs. Cruickshank, Hargraves, and Houghton, made some brief remarks on the metal, and after a vote of thanks had been accorded the author, the proceedings terminated.

11th September, 1890.

Mr. A. D. NELSON, President, in the Chair.

Donation.—The President announced having received a large-framed photograph from Mr. Lawrence Hargrave of that gentleman's last improved flying-machine, and that the Council had thanked the donor for his gift.

Appointment of Auditors.—On the motion of Mr. R. Scott, seconded by Mr. Thorpe, Messrs. J. R. Haycroft and J. Elder were appointed Auditors for the year.

Paper "On the Dangers Arising from the Use of Clay in Dams, Embankments, &c.," by Mr. Angus Mackay.—The discussion was opened by Mr. Shellshear, who was followed by Messrs. Henson, Seaver, Haycroft, Poole, Salmond, and Dr. Storer. Mr. Mackay having replied to the various comments on his paper, was accorded a vote of thanks.

The meeting then terminated.

PART II.

PAPERS.

PART II.

PAPERS.

20TH MARCH, 1890.

ADDRESS BY THE PRESIDENT,

MR. A. D NELSON.

GENTLEMEN,—I have to thank you for re-electing me as your President for the ensuing year, and as the duty devolves upon me to deliver an address, this being the first meeting in the year, I trust you will not expect an extensive or elaborate expression of opinion upon the few questions I may touch upon to-night, as I need hardly say I have been labouring under a great disadvantage, being exceedingly unwell for the past few weeks; this has prevented me giving due consideration to the important questions which I intended bringing before you. I must, therefore, apologise for any short-comings which may appear in my address; and, in stepping into the arena, I must ask your attention, in the first place, to a question which, to the majority of us, as mechanical engineers, is of very keen interest.

We have had in New South Wales a cloud of depression hanging over us for a very considerable period, and which has had the effect of very much reducing the number of men employed in our workshops and offices, and as a consequence reducing the output of material which, under different circumstances, we should have. When I take up periodicals

and newspapers from other countries and glance over items of interest to the engineer, I often feel that our engineers labour under more difficulties and disadvantages than those of any other country.

In America, for some time past, trade has revived to a very considerable extent. Some six months after the revival of trade in America we find a change has taken place in Great Britain and various places in the Old World, absorbing to a large extent the labour which has been walking the streets for a lengthened period—a circumstance not only beneficial to the *employé*, but to the capitalist also. Patiently have I waited, thinking that this colony would ere this have seen the gleam of light radiating amongst us, dispelling the dark cloud, and causing the engineering industries to thrive and prosper. Many of us have tried to solve this industrial problem, but have failed in our efforts, and I regret to say I have no information to offer concerning any large engineering works having been carried out during the year, although I might say plants of machinery for the Government and Corporations have been and are now being erected; but, unfortunately for the engineers, they were not manufactured in the colony. It must seem strange, not only to the residents of the colony, but to those who manufacture our machinery in other parts of the world, that we, having everything that is necessary for manufacturing, every mineral and every facility to manufacture or construct whatever we require, I say, it must seem strange that we should seek in foreign parts for almost every particle of machinery we use. Even to the very Government, whose duty it should be to endeavour to build up the iron industry here, they evidently fail to see the force or necessity to place the colony in an independent position for its ironwork. Will the day ever come when the ores, which are lying in the bowels of the earth, in tons innumerable, are raised, smelted and forged for the use of mankind; or shall they continue to be hidden as they have been for centuries past? Can we find a man who has brain power sufficient to grapple with one of the greatest difficulties the engineers of the colony have to contend against? Is there no

possibility of burying, to some extent, political differences, and allowing the colony to progress in such a manner that it will give employment, not only to the surplus labour now existing, but to tens of thousands of people who may come amongst us to cast their lot with us. Surely the day is not far distant when some change will take place that will relieve the now seemingly almost insurmountable difficulties which stare the engineering community in the face.

Glancing at the exports of Great Britain I observe by the Board of Trade returns the total exports for the year 1889 was £248,092,000 worth. The chief items are metals, machinery and raw materials. The export of metals has increased considerably, especially in the form of machinery and engines, consequently if exports from one country increase there must be a corresponding increase of imports in others. In a colony like ours there should be a large scope for engineers. There are many matters of vital importance to the interests of this colony which rest entirely in the hands of the Government. Amongst these the interest of the engineering community is prominent. We are well aware of the fact that the Government are spending vast sums of money on education with the hope of qualifying our youths to fill positions in life, to compete with people in other parts of the world, and yet when their education is completed, and they are turned upon the world, there is no opportunity to obtain employment in that path of life which the Government have thought fit to educate them for. If we are not to be a manufacturing people, then, I maintain, the large amount of money expended is to a very great extent thrown away. Another item which I claim as a question worthy of the consideration of the Government and the people in this colony is that of settling the people upon the land. It is not my desire or wish to touch upon one theory or another, either single tax or any political question, but it is my desire to try to show what can be done in this direction by an active and energetic Government.

I will now take the problem of water supply, which is so little realised, as the most important factor in agriculture. In America

along the coast of the Atlantic, there is abundance of rain; in some parts heavy snow storms fall in winter, which are retained by the various forests covering the hills; therefore the streams do not run dry in summer, and a drought of a month is of rare occurrence; but in other portions the rainfall is extremely light; the small streams run dry, and a drought of over a month is not uncommon; still there is never a failure of crops over any extended area. In many parts of America the greater part of the rain falls at one time in the winter—a time it cannot be used. In the ordinary course of things the water would flow to the bed rock of the river, and flow on without benefiting the soil. The following extract from *Scribner's Magazine*, is of interest:—"Until very recently the people of the United States have not been much interested in this section from an agricultural standpoint. Up to this time there has been an abundance of good land unoccupied in the Mississippi Valley. The Far West has been the land of mines and ranches—a desert terrible in its vastness and barrenness. But nearly all the good farming land has been taken up. The Dakotas, which have been receiving and absorbing the mass of emigrants since the lands of Nebraska, Kansas, Minnesota have been appropriated, are now well settled states. When Oklahama was recently opened twice as many settlers stood ready as there was land for them to occupy; still the great stream of European emigration rolls in upon us—the Eastern States still send their young men West. Where are all these new farmers to find the farms to work? In their search for them they are making their way into every part of the Western Plateau; they are at last by necessity forced to turn to the arid region hitherto unthought of as a field for agriculture. As these pioneers press on into this unknown land they find the common picture of it misleading. They find that if the country be a desert it is so only from lack of water, and not from the sterility of the soil. Wherever water is found in sufficient quantity they see crops in no wise inferior to the best grown in the Eastern or Central States. In the south-west they find many productions which cannot be grown anywhere else in the country. Most important of all, they find that the

rainfall, though small, is almost everywhere sufficient for farming, if it did not mass itself in unfavourable times of the year and disappear as rapidly. The problem is to so regulate, increase, or store this small water supply as to make fruitful this rich but idle soil. It is a problem full of interest to every farmer in the Great West, but on a larger scale a problem of the utmost moment to the whole of the United States, if not to the world. All land in the East is either in the hands of private owners, or covered with forests on mountain sides which are almost untillable. Nearly all the land of the central plain that can be cultivated by the natural water supply is already appropriated, and every acre will be taken up within a decade. In the west lies this immense territory—two-fifths of the whole—the greater part of whose soil is capable of rich return, but which now lies unproductive. Can this land in any way be covered with farms, and these millions of acres made productive? What a problem is this both for the present and still more for the future of our country and the overcrowded world. It is the problem of a reclamation of an empire. The people of the West are attacking this problem from every side. Governors are urging its importance in their messages, and legislators are memorialising Congress to turn their attention to the unrivalled fitness of their particular State or Territory for the trial of irrigation."

If the people of America are attacking the problem which is of such vital importance to their country, and not only their country, but to the whole world, and are clearly demonstrating how water can be stored, how irrigation can be carried out, how land which to-day is arid can be converted into fertile plains, where people can settle and bring up their families, where the surplus population from other parts of the world can flow and become part of the community, why cannot we do the same?

My experience of various large tracts of our country is that farmers could settle upon it favourably if it were not for the difficulty of the water supply. When we observe the Americans have gone back as far into the Western Territory as possible, where they have damned up the waters in the mountains, laid

flumes and channels to an extent of 60 miles in length in many places to pour their waters over land which was valueless until the combination of capital and energy culminated in reservoirs to store their water during the whole year. If it is possible to do these things in the far west of America, I am sure it is equally possible in the interior of New South Wales, were the laws of the country are of such a nature as to permit the combination of capital and energy to step in and so regulate the water supply for irrigation purposes, as to enable the farmer to feel his independence of the rainfall, for the want of which so many of our farmers are very often ruined. Concluding my remarks on irrigation, I am disposed to think that if tracts of land owned by the Government could be irrigated by private enterprise under proper conditions it would be the means of settling farmers upon the land on a most extensive scale, the Government to let the land to people who desired to live upon it, allowing the company to make its own arrangements *re* irrigation.

I feel this question is worthy the consideration of all practical engineers and also of the Government if they desire to have people settled upon the land and to see the colony prosperous.

Another question which occupies the minds of some of our most prominent engineers here and all over the world is that of Electric Traction and Electric Lighting. If I am correctly informed, the Government or Railway Commissioners are exceedingly anxious to try experiments in electric traction. Now, much has been written recently in the public press with regard to the effects of the so-called panic which existed in New York some time back. There is no doubt but the articles which were written in many papers and periodicals throughout the world had the effect of damping the ardour of a large number of people who, prior to these articles being published, were anxious that electric lighting and electric traction should soon be accomplished facts. In some parts of England there was great dissatisfaction with the overhead electric lighting wires. In Exeter the local Electric Lighting Company were threatened with a prohibition of the extension, and in Dundee the consent of the Police Commission

for the erection of a single electric light wire was refused. Again in Glasgow the Corporation have been induced to affirm that $3\frac{1}{2}$ miles of overhead electric wires and cables constituted a risk to life and property. This was all the outcome of the panic created in New York. At this juncture the history of the agitation which has given rise to these troubles may be studied with advantage. It must not be forgotten that the outcry for the removal of the overhead wires in the streets of New York arose in the first instance not so much because of the dangerous currents, but rather because of the unsightliness of the wires and their well-known insecurity. As customary in the first or early periods of such events as the electric lighting of cities and towns (illustrations of which we have in our own colony), things are hurriedly run up in obedience to the pressing demands for the light, and the fact of there being no special officers to supervise on behalf of the public, invariably the wires are of the cheapest quality, and erected in the cheapest manner possible; in many instances, they are suddenly angling over into the streets, or coming into contact with property, which is very objectionable. This is the cause of the outcry, and as it seemed to suit the Municipal authorities and the various parties in power in New York to order the removal of all wires to conduits, an order was easily obtained, and a Commission was formed—called the Board of Electrical Control—to carry these decisions through. There is no doubt, looking at the matter in all its various phases, one of the most prominent being jealousy between the rival systems of Electric Lighting and Gas, they had evidently formed a conspiracy to use none but so-called harmless current, which is some company's speciality. We are informed that even the Press lent itself, or was deluded by this faction; and, in a very short space of time, every accident in the streets of New York was traced to high tension and alternating currents. This, then, is a brief summary of the cause of all the trouble which has arisen in New York with regard to overhead electric lighting. It is on record that the experience of a London Electric Supply Corporation shows only one serious accident has occurred in connection with the Comany's

wires, and that could not be conclusively traceable to the electric current. As a matter of fact, more progress has been made in Electric Lighting during the present year than ever, although a severe check was given at the onset by obstructive legislation and opposition of Gas Companies. In London, Electric Lighting has advanced very rapidly, and it seems as though many of the provincial towns have stepped into the sphere of activity, for the total number of "provisional orders" for provincial towns, deposited with the Board of Trade before the 19th of last December, was 157, and the towns numbering in all 118. Various companies and firms have also put in 112 applications, whilst local authorities have put in 45. This shows that anything which has been written concerning overhead lighting in America, irrespective of the fact that the wires were pulled down in the streets, and their streets put into darkness, has had very little effect in England, for a large number of English cities and towns are making every preparation for dispensing with the old system of gas lighting, and are accepting the more modern system of electricity. On every hand we hear of works being extended to meet the increased demand for this special class of work, whilst in order to keep pace with the extraordinary boom of business amalgamation of firms has taken place. To give a rough idea of the amount of business done in this line in England, there is one firm which, during the year 1889, completed, and held orders to be completed, engines alone for driving dynamos equal to 18,000 h.p. They have in previous years supplied similar engines to the extent of 12,000 h.p. In fact, electric lighting has opened up new channels, not only for the artisan, but the capitalist also; and it is to be hoped, in the event of our Government deciding to introduce an electric tramway, they will take every precaution in obtaining advice which will enable them to procure not that which is the lowest in cost, but a system which will be the best known up to date. The information published now with regard to the electric light is very extensive; even manufacturers in their pamphlets give valuable information to engineers who are desirous of improving their experience in this line, and I trust that whatever the ultimate result may be, we will not enter into any transaction of this kind

until such times as we have decided conclusively which is the best system to adopt. In concluding my remarks upon electricity, I will quote from a very recent journal received from America, one which is considered a great authority on manufacture. It bears date of January, 1890, and it states that the Westinghouse Electric and Manufacturing Co. has just closed a contract with the Weelametta Light Company for a plant of 10,000 incandescent lamps and 100 Arc lamps together with all wire and machinery necessary for operating the same, and the current is to be carried 12 miles before being distributed, a thing never before attempted in America, for which purpose a specially constructed machine capable of producing a current of 4,000 volts. is to be used and the cost of the entire plant is to be 200,000 dollars. This is done even in the face of New York chopping down her wires, and perhaps her action was wise under the circumstances, not that there is any danger as I have shown from the experience of the London Company, who make it a point to put in nothing but the best prepared wires and complete their work in a satisfactory manner. I have in the course of my remarks wandered away a considerable distance from our own colony; this has been necessitated because of the small amount of engineering work, as I have already stated, being carried out in the colony.

I will now touch upon a question or two which I consider to be of importance. For years past we have had strict supervision of all marine boilers manufactured in the colony or coming here in steamers. We have had a staff of men qualified, and who carry out the duties of their office in a manner which I have every reason to believe satisfactory to all parties concerned. It is a question which has very often crossed my mind during my career as an engineer that the Government take such precaution with regard to marine boilers and allow land boilers to be constructed, repaired, or arranged in whatever manner the proprietor thinks fit.

My experience of some of the boilers in the interior of the colony, nay more, in the very heart of Sydney, is of such a nature that I say unhesitatingly that it is the duty of the Government to

appoint a qualified man to examine boilers and machinery and compel the proprietors to carry out the instruction he might give to them under a penalty of a severe fine. Invariably I find so long as the engine goes round and the machinery is kept in motion the proprietor is satisfied; he cares not what the probable risk is, nor is he aware of the fact that through defects existing in the machinery he is paying hundreds of pounds for coal which, under different circumstances, there would be no necessity for; and although the proprietor of machinery may be, to a certain extent, inconvenienced by the supervision, I have no hesitation in saying the information he would derive and the benefits accruing from the information would far more than compensate him for the periodical inspection of boilers. This was considered by the Engineering Association some years ago; but like many other matters which have been brought before the Government, received considerable attention for a week or so, and ultimately is shelved for ever. While I admit it might seem out of place for this Association to make a suggestion on the point, yet however much it might seem unwise, nevertheless it is our duty as practical men to point out to the Government of the day and the people any risks which exist to life or property.

There is one important question which I trust during the ensuing year will receive careful consideration from some member of this Association, viz., the report by Mr. Price Williams on our railways. It is deserving the best consideration of every practical man in the colony, for if it is allowed to go unchallenged, it will reflect very much indeed upon the ability and qualifications of many of the engineers in New South Wales. I have no hesitation in saying that had it not been for the circumstance of my indisposition, I would have dealt with this in an exhaustive manner in this address, for I cannot understand how either the Government, or those who represent them on the Railway Commission, can accept such a sweeping assertion as is made in the report. The contradictions existing on the face of it are so flagrant, that it does not require a man of very extensive brain power to glean sufficient information to draw conclusions which do not reflect credit on

those who accepted the report. We have now arrived at that condition in this colony, so far as railways are concerned, that those in power believe there is no man here qualified to do anything in the way of organising, supervising or carrying out railway work; every man who is required is imported. If we want a clerk he must be imported; if we want an engineer we must import him, and I say, with all due respect to the Government, they may have been guided by a desire to remove what was called poltical influence; but, unfortunately, they have succeeded in the new *régime*, according to the Press, in establishing what may be called friendly patronage. If practical men are not to deal with this question, whose duty it is to see that the sum of one and a-half millions of money is not squandered? We cannot expect the commercial man to express an opinion on a practical question, and if the engineer will not, then the people of the colony must be simply robbed by actions of this kind. This question must be ventilated, and should be in the public Press, and the thoughts and ideas should emanate from the members of the Engineering community.

I trust ere this session closes a paper on this question will be read before us, so that we may be granted an opportunity to express an opinion, so that the public Press may understand what the views of practical and experienced men are. The peculiarity with regard to filling various offices in the Railway Department is so significant when compared with the appointment of officers to the Water Conservation branch that it tells its own tale. The latter body have selected men of intelligence, men of large experience in the colonies. They found there was no necessity to import them, and I claim if they can obtain their officers in New South Wales the Railway Department also could do the same, for according to the theory laid down by the present Minister of Works in an address delivered a few weeks ago, he claimed that engineers in this colony were equal to any in the world.

10TH OCTOBER, 1889.

THE EPICYCLIC GRAB DREDGER.

BY H. DAVIES.

THE mere novelty of a design, the author is aware, is not sufficient ground for pressing it upon public notice; but he hopes to satisfy the gentlemen he has the pleasure of addressing this evening, that the subject matter of this paper is not only a new contrivance, but that it possesses features which render it distinctly superior to any other machine for effecting similar operations.

Our modern grab dredges are descendants from an exceedingly ancient family; but, unlike some scions of old stock, instead of falling into a state of uselessness and decay, they have, in recent times, adapted themselves to the new sources of power, and have proved themselves to possess under their alliance with steam, unexpected usefulness, and they are continually improving and increasing in effectiveness.

In New South Wales alone, the author believes more than a dozen patents in connection with grab-dredging have been granted within the last two years, and in Victoria considerably more than that number of rights have been acquired in the same period; while Queensland and the other Australian colonies have all been active in this branch of mechanical engineering. The economy, efficiency, and convenience attained by using these machines has been so marked that their numbers are increasing daily; and he believes that the near future will witness a still greater perception of the capacity of the grab-dredger for dealing with certain classes of work.

He will now direct your attention to these working models and drawings, by means of which he wishes to illustrate some of

the most modern of our grab-dredgers; and particularly to this model of the excellent machine made by Messrs. Priestman Brothers, and to this miniature Epicyclic Dredger, which he will presently put into actual operation, so that you may witness their respective methods of working, and judge of their relative values.

Grabs have been designed to work by means of one, two and three chains. He will not attempt to occupy your time by describing all these machines, but as there may be some members here whose practice has not brought them into contact with these instruments, he will briefly point out the peculiar construction of a good sample of each kind.

The flat model exhibited is not meant to be a scale representation of any particular grab, but it is a fair sample of the system of pawls, triggers and catches requisite to the whole system of single-chain grabs. Mr. Stothert, in speaking of the single-chain grab, during a discussion at a meeting of the Institute of Civil Engineers, London, gave an account of an excellent performance by grabs of this description.

Two ten-ton cranes, each working a single chain grab of 40 cubic feet capacity, were placed on a hopper barge having a capacity of 500 tons. These grabs brought up 50 per cent. more than their supposed load or 3 tons per cut. Each crane made as many as 60 lifts in one hour, or 180 tons per crane, the two machines thus placing 360 tons in the hopper every hour—filling it, and the barge being ready for moving out to sea in less than two hours. It must be allowed that such a performance is very good work. But Mr. Stothert, who is a manufacturer of these machines, while maintaining that they have good qualities of their own not to be overlooked, and particularly that this form can be hooked on to any ordinary jib crane, and immediately put to work, admitted that the double-chain system of Messrs. Priestman Brothers was superior.

The objections to the single chain system are as follows:—

1. The catches and triggers which complicate the grab are subject to rough usage, and are submerged and brought into contact with the rough and foul stuff being dredged, and they are

as a consequence very liable to wear, damage and fouling, thereby causing loss of time.

2. If a snag or other immovable object be seized under water, great trouble is involved in releasing this form of grab, and divers may be required to set it free, or at times the grab may even be lost.

3. If the chain breaks, much expense is caused in recovering the grab, whereas those having more than one chain will always have one connection left.

4. They will only discharge at the particular height for which the gear has been adjusted.

The next model is a perfect reduction of the best type of double-chain close-tine grab. Its action and structure are so simple as to require little description, and its performance is excellent.

The treble-chain system requires a special grab, and also a special crane, both parts being the subject of a patent granted to Mr. C. W. Maclean, of Melbourne. You see by the drawing exhibited that this is a ponderous and somewhat complicated machine. The author has not seen these dredges, but he believes there are several at work on the Yarra, and they are reported to be exceedingly powerful and effective contrivances. The complication of its parts, its weight, and the fact that its action is entirely dependent on chains working in cupped or pitch wheels, will be found objectionable features, he thinks, in this dredger, and sufficient, notwithstanding its effectiveness, to prevent its becoming a powerful rival to the double-chain machines.

The double-chain system is at the present time best known by the examples manufactured by Messrs. Rose, Downs, and Thompson, Mr. J. B. Wilson, and by Messrs. Priestman Brothers. Messrs. Rose, Downs and Thompson's gear is somewhat complicated. It consists, as you may observe, practically of two winches, one to each chain, and one winch driven off the other by a pitched-chain messenger. Mr. Wilson's gear also, is in fact a two-winch system, one winch being driven by a messenger-chain connecting it with the other winch.

The author will now call your attention to the dredger of the Messrs. Priestman. The grab dredging-gear patented by this firm is very generally considered the best contrivance of its sort now known, and he trusts that nothing he may say in this Paper will be construed as indicating that he has a poor opinion of that firm's excellent mechanism; on the contrary, looking upon the Priestman crane as the best, he has attempted to study out an improvement upon it, and unless he has succeeded in designing a gear which distinctly overcomes some acknowledged difficulty and effects a superior result, then the Epicyclic Dredger has no excuse for remaining upon the scene. In the Priestman crane the closing and hoisting chain is wound on to a winch barrel, and the opening chain is taken in by means of a heavy weight suspended from a number of pulleys over which the chain is rove. The opening chain is passed under a cupped pulley controlled by a brake, and it is by this brake holding the chain that the grab is made to release its spoil. This weight may vary from 43 cwt. with a four-sheave purchase, to 90 cwt. with ten sheaves, according to the depth at which the dredging is being done; and supposing that the vertical range of the weight is 8ft. in each case, the former arrangement would suit for a range of about 11 fathoms for the grab, and the latter for nearly 27 fathoms range, the strain on the fall of the chain being in the former case $5\frac{1}{2}$cwt. and in the latter $4\frac{1}{2}$cwt. It is this tension on the opening chain which tends to lift the grab off the ground precisely when it is desirable that every ounce of its weight should assist in forcing its cutting edges into the spoil, that strikes an observer as the most obvious defect in this system. Cupped wheels and pitch chains, such as are used for the break-gear, are also things to be got rid of, if possible. The author is aware that Mr. Priestman contends that his dredgers may be worked without strain on the opening chain during the time in which the cut is being made. His argument is this: That for any given depth of dredging the weight on the opening gear should be reduced until the pendant chain will so nearly balance it that the momentum, acquired during the fall of the grab, will cause the chain to run

out and the weight to rise some little time after the ground has been struck. The driver should then catch this slack chain smartly with his brake, and hold it while the cut is made. This feat may be accomplished by accident, but in ordinary practice it is not. In the event of the Priestman dredger seizing a snag or other thing which cannot be lifted, it is a tedious and difficult operation to release it. The attendants must in such a case lash the two chains together, some slack being passed out on the closing chain. Now, on heaving with the crane, the grab will open and come up. These grabs weigh as much as two tons, and require very careful handling; it will be evident that this manœuvering is troublesome. Shingle, mud and broken rock can be raised in first-rate style by these machines, and so can free sand and some clays, but hard clays and some impacted and cemented sands almost defy the attacks of these tools. The machine the author will now describe has been designed with an eye to removing some of the difficulties he has mentioned as peculiar to the working of the best form of grab dredges hitherto known, and also with the hope that the attacking power of the grab might be made more suitable for operating on ground which is now considered too obstinate for it to deal with. It will be seen, on inspection of plates VI and VII, Figs. 1, 2 and 3, illustrating his invention, that it consists of a very simple arrangement of two loose barrels (E and F) placed on the main shaft (D) of a crane or winch, one barrel (F) for the opening chain and one (E) for the closing chain. Each barrel has an independent brake (G′ and G″), and the pair of barrels are driven off the main shaft by a nest of epicyclic wheels (O,O) and (P,P). It will be noticed that the two barrels, as shown, are of different diameters, but he claims to make them either according to the illustration, or to make them of similar diameters. The two barrels of the model before you, for instance, are of the same size. The method of giving motion to the shaft (D) may also be varied. In Figs. 1, 2 and 3, Plate VI, this shaft is shown as being driven by a crank-arm (L), fixed in a disc (K), keyed on the shaft, The exposed end of the crank-arm engages in a radial slot (M), wrought in the friction-wheel (I). This friction-wheel is driven

by being brought into contact with the friction-pulley (H), which is fixed on the engine shaft. The wheel (I) is caused to advance for making contact or to recede by turning the eccentric (J), which is shipped loosely on the shaft (D), by means of the lever (J′), and the wheel, which runs freely on this eccentric, is thus moved through the very small arc required to place it in contact either with the driving pulley (H), or the retarding brake (J″).

The Epicyclic machine will make its cut with an absolutely slack opening chain; it has no pitch-chains or cupped wheels; it will release a snag or other immovable object in an instant, and take a fresh bite without being even raised out of the water; it uses two small chains, or ropes if desired, instead of a large chain and a small one, and each of its chains or ropes must do exactly half the work. If the ground is of a hard nature this machine can be caused to repeatedly bite or gnaw the surface, scarifying and breaking up the ground before making the final cut. He hopes directly to be able to show by experiment that on easily-penetrated ground his gear will do 20 per cent. more work than the Priestman gear can, and on hard ground 100 per cent. more. The crane as made on his method is also a remarkably useful machine for general lifting purposes. Hook on one chain only and we have a a quick purchase for light loads, and when both are used a slow motion for heavy lifts. By hooking both chains on at different parts of the log or pile, it may be handled very conveniently, since we may bring it vertically or end on through a hatch, then incline it or bring it horizontal, just as required. This crane will also work a bailer, which may hold 600 or 800 gallons, and discharge that quantity each minute, or say, 40,000 gallons in each hour—a useful quality in a machine intended to clear flooded works, &c.

Before making experiments the author may say that he has proportioned the model of the Priestman gear faithfully after a good example of one of that firm's dredgers, but that he has adjusted the strain on the opening chain to give more favourable conditions in the model than exist in the actual dredger, the strain on the chain being in the model ·14 of the grab's weight, and in the actual dredger ·16 of the grab's weight.

He will first operate the Priestman model on unpacked sand, making four cuts and weighing the total spoil raised, and after that he will make the same number of cuts with the Epicyclic gear and note the difference of weight in spoil raised. It will be observed that he has not reproduced the cupped wheel and brake-band, as applied by Priestman to the opening chain, simply because it saved complication to omit it, and the same effect is obtained by seizing the opening chain with the hand.

In working grab dredgers the bucket is usually allowed to fall upon the ground with momentum, but for these experimental trials he proposes to lower the grab gently, so that there may be no question as to variations of height of fall and velocity. Both these conditions are favourable to the Priestman model, because the brake causes additional frictional resistance, and because the Epicyclic dredger allows the grab to fall more freely than can any machine in which the grab has to heave up a ponderous weight as it falls, and therefore dropping the grab with added momentum must be favourable to the latter.

In each case he will also show the method of releasing the grab when it has become fast to a snag. Then he will operate each model on hard packed sand, and show how much more effective the new gear is on this resisting material. After that he will show how the crane built on his method works for ordinary lifting purposes, and you will see that with a light load on one chain only, the engine will make for any given lift but half the number of turns that would be made with a heavy load or two chains; and finally he will show the crane working as a bailer.

Having now attached the model of the close-tined grab (before exhibited to you as the most approved form of such apparatus to the Priestman gearing) he will proceed to make four cuts on this box of loose but damp sea-sand. Seizing the opening chain he allows the expanded grab gently to descend and rest upon the spoil which is to be raised; then releases the opening chain, and heaves on the closing and lifting chain. You will perceive that as the cutting edges approach each other the grab descends somewhat, and, as a consequence, hauls on the opening chain, thus lifting the

counterweight, and depriving the grab not only of the proportion of the counterpoise weight due to the block and chain gearing, but also of the increase of that strain due to frictional resistance, the sum of these undesirable forces amounting to probably one-fifth of the grab's weight. The grab being closed, we continue winding the closing chain upon the winch-barrel, thus raising the machine and the contained sand. Again seizing the opening chain and lowering away with the winch and thus discharge the spoil. The four cuts of sand now secured have a gross weight of 13·5 pounds, the time occupied by the work being four minutes. We will now connect the Epicyclic gearing to the same grab, and, applying the brake of the spinning barrel of the winch, lower the opened grab on to the loose and damp sand as before. After the grab has gently come to rest on the sand, release all brakes, and continue to lower away for a little time on the winch, so as to make the opening chain quite slack, and a couple of feet, as per scale, to spare. Now apply the break of the opening barrel once more and wind away with the winch, thus hauling on the closing chain. Observe the opening chain, and you will see that it remains perfectly free, although the excavator penetrates more deeply than it did in the former experiment. As soon as the grab is closed, release the brake and continue winding with the winch. You will note that the two chains adjust themselves, each accepting half the load, and the grab and spoil are raised. Again apply the opening brake and lower away with the winch, releasing the sand from the opened excavator. As before, we will make four such cuts. The gross weight amounts to seventeen pounds, and the time required was four minutes. By comparing these figures, it will be seen that the Epicyclic has lifted 3·5 pounds more than the Priestman in the same time, or 25·9 per cent. more.

We will now make some comparative trials of the same mechanisms on the damp sand rammed into a consolidated mass, so as to represent some of the more refractory materials which grabs find it so difficult to operate upon. As the Epicyclic is connected we will take it first this time. The opening brake being applied, we lower away with the winch and deposit the open grab

gently upon the now hardened mass of sand. To make any serious impression on this surface, the author must bring the scarifying or breaking-up action of his machine into force. To effect this, he releases the opening break and pays out both chains quite slack; then applies the opening brake and heaves on the closing chains, partly closing the grab; then again releasing the opening brake, he again pays out slack chain, and this time applies the closing brake and heaves on the opening chain, thus re-opening the grab; and so on, opening and partly closing the grab three times before entirely closing and lifting it and the contained sand. This entire series of motions he repeats four times (four charges total up to 12·5lb.), the time required being 6 minutes. Now to attach the excavator to the Priestman gear for trial on hard ground. You will here observe that this method allows of but one action, and therefore the grab is handled just as it was in the first trial on soft sand. Having made the four cuts and weighed the four charges, we find that four pounds of sand have been secured in 4 minutes, the Epicyclic thus raising 8·5 pounds, or 212·5 per cent. more than the Priestman, but requiring 6 minutes or 50 per cent. more time. Allowing for time, the absolute increase of effect due to his patent gear is 108·3 per cent. when working on hard sand.

Having now terminated his dredging experiments, he will illustrate the recovery of a fouled grab by both methods, the Priestman first. Placing this cloth on the sand, he lowers the extended grab on to it, and causes it to close on the fabric, which, you will please assume, to be something that cannot be moved. The difficulty now is to disgorge this object and recover the excavator. To effect this, we must lower away with the winch, paying out, say, four feet of the slack upon the closing and hoisting chain. Now put a secure lashing round both the hoisting and the opening chain just above the water line, on heaving on the winch the excavator opens and releases the immovable object, and is brought up abnormally suspended by the opening chain. If the water be of considerable depth the lashings must be removed and replaced several times before the grab can be placed on the barge and re-started.

We will now connect the Epicyclic gear and foul the grab as before, by simply applying the brake of the closing barrel, first paying out slack chain, and then heaving on the opening chain the grab is at once set free, and can be moved from the neighbourhood of the snag, and dredging resumed without hoisting the excavator.

The author will now show you that the crane, which is fitted with his patent gear, with the object of making it capable of working a grab for dredging, loses none of its usefulness as an ordinary crane, but on the contrary is a far more effective lifting machine than any of those in general use. Hanging this light case from one of the chains from which the grab has been detached, and applying the brake to the barrel of the other chain, it can be hoisted to the jib-head in six turns of the main shaft. Now let us suppose that this case is a heavy package of machinery, not to be whipped up in that speedy manner. Simply hook both chains on to it and hoist, and the case is now lifted to the jib head with twelve turns of the main shaft. This small log may be considered a pile or part of a cargo of timber; we will attach both chains, each one at a point about equi-distant from the centre of the log. Now while lifting with the winch, we can, by adjusting the brakes, place the log either horizontally, vertically, or at any angle of inclination; or we turn it end for end while either lifting or lowering.

This model of a bailing tank may be supposed to have a capacity of 800 gallons; it is rectangular and open-topped. It has a chain-bridle attached about half-way down one side for connecting opening chain, and another bridle near the lip of the other side for attaching the closing chain. Connect the chains, and, placing the machine over this tank of water, you can see it is possible by manipulating the winch, much the same as for dredging, to lower the bailer with the mouth turned vertically into the water, fill it, turn the mouth horizontally, lift it in that position, and then again capsize and discharge it, ready again to descend and re-charge.

[No discussion took place on this paper, as Mr. Davies stated that members would be afforded an opportunity of witnessing a full-sized machine, now in course of construction, in operation at an early date.—Ed.]

10th April, 1890.

THE PREVENTION OF DAMAGE TO RIVER BANKS BY FLOOD WATERS AND THE REGULATION OF RIVER CHANNELS.

By W. SEYMOUR WELLS, Assoc. M., Inst. C.E.

The object of the author in writing this paper is to draw the attention of the members of this Association, and to invite discussion upon a matter of considerable interest and importance to a large number of people in this colony, *i.e.*, the prevention of damage to river banks by flood waters and the regulation of river channels.

Any person who has taken notice of the alterations which are constantly occurring in the contours of river channels must also have noticed that large areas of land have been lost through such changes. It is during the periods which elapsed between the attainment of maximum flood, and the subsidence of the waters to their normal level, that these losses occur—thus a paddock having a stream for its boundary often becomes less in area after each successive freshet or flood.

To devise means of conserving the banks, and preventing rivers from changing their courses, is the business of the engineer, who must consider, in their most minute particulars, a great number of phases of the different questions which present themselves, before he can finally decide upon any definite plans for accomplishing the purpose in view.

Various methods have been adopted by engineers for the protection of river banks, and they are as follows :—

I., Fascines; II., Timber sheeting; III., Iron sheeting; IV., Crib-work; V., Stone pitching; VI., Retaining walls; VII., Groins. They are all briefly described by Professor Rankine in his valuable work on Civil Engineering—but, excepting the first (fascining) and the fourth (crib-work), all of the above methods are too expensive to apply to any but special cases. Both of these more economical plans are specially adapted for use in this colony where timber and brushwood are so plentiful.

Before fascining, the banks should be sloped according to the nature of the soil of which they are composed, after which a beard or apron of fascines should be laid as a bottom course, from the river bed upwards, the fascines lying with their length up and down the slope, the upper ends fastened by wire to stakes, and the lower ends under water held in position by loading them with stones; at a height of about three feet above water level, the fascines out should be laid horizontally along the slope-breaking joint with each other in the courses, with their bushy or leafy ends up stream, so that they may catch as much as possible of the soil and solid matter carried in suspension by the waters. For this class of work the ti-tree, she-oak and pine brushes are the best to be obtained indigenous to the colony. Fascining for this class of work is the cheapest and most effective that can be adopted. There is an avoidance of the danger attendant upon offering distinct resistance to the flow of water by means of retaining walls, timber and iron sheeting, &c., where if the up-stream ends are not carefully and often expensively secured, the water forces a passage between the work and the bank, leading to greater trouble than existed before the remedial measures were taken. Fascines admit of the water passing through them, offering only a partial resistance to the flow, at the same time retarding the velocity of the stream closest to the banks, and yet all the while they are gathering matter which assists to strengthen the latter against the action of future floods or freshes. One danger to be feared in the use of fascines is from fire, which may destroy in a short time the whole of a work of this kind.

The protection of banks with crib-work is greatly practised in

America, where such work is also extensively used for dams, abutments to bridges, &c., and is effectual in most cases. The author has used it in washaways where bridges have been endangered, and as a protection to embankments and roadways against the action of water, with most satisfactory results.

If an engineer has an unlimited amount of money at his disposal, he will probably adopt one of the other more substantial and expensive methods, but where he has to consider cost as well as efficiency, fascining presents the necessary requirements.

Having thus briefly dealt with the cheapest methods of effecting the stability of river banks, the author will now consider the best means of securing the channels and regulating the currents of rivers.

A river having a rocky bed may be said to be in a state of stability. When the bed is stony, or gravelly, it is stable in the normal state, and unstable in the flooded state of the river. "An earthy bed," Rankine states, "is in its usual condition either *just stable and no more, or permanently unstable.*" As an instance of an unstable bed during flood, may be cited the case of the Shoalhaven River, where, after a fresh, the sand scours out round the piers of the Nowra Bridge to a depth of 3 or 4 feet; but after a short period elapses, from the time the river has subsided to its normal level, the holes that have been formed gradually silt or become filled up again, so that no permanent damage has ensued.

The Hunter and Goulburn Rivers afford instances of gravelly beds, which are always in a state of instability during even small freshes. In each of these rivers, the current of to-day may be running close to the right bank; to morrow there may be a fresh, and, after the water has subsided, it will frequently be seen that the channel has been transferred to the left bank. When a river has both unstable banks and bottom, the channel is constantly altering its course; this is notably the case with the Hunter River. The banks of this stream being, for the most part, composed of rich friable alluvial soil, are easily eroded and undermined even by slight freshets, but when a heavy flood has subsided, leaving the banks highly saturated, the latter begin to show signs of yielding,

and, mostly when the water is within 2 or 3 feet of its normal level, large masses of earth become detached and flop into the stream, which carries the soil away in suspension to deposit somewhere lower down stream, generally at a point next or in proximity to the convex bank of a turn in the river, where the velocity of flow is less than it is next to the concave bank. Rankine states that "a channel tends to become continually more and more curved," and this the author has noticed with regard to all rivers he has yet had to do with. As an instance of an encroachment made by the Hunter River upon its bank, at one particular turn near the township of Denman may be cited the following:—In the year 1886, at a point between the Denman Bridge and Denman, a strip of land in the turn shown on sketch disappeared. This strip was about 500 feet long and 30 feet wide. The next serious encroachment took place in February, 1887, after which the author had a protecting fence erected about 20 feet distant from the edge of the bank. In August, 1887, it became necessary to remove about 20 rods of the fence to prevent it from falling into the river, so that in the short space of six months a piece of land at this one point of about 17 perches in area had been swept away. It will be seen from sketch that the river at this point has changed its course considerably—for what is now a dry bed of shingle on the convex side of the curve was twenty years ago the deepest part of the channel. The author proposed that the concave bank should be battered and protected by fascining; that a cut should be made through the old bed of the river, and that brushwood spurs should be thrown out into the stream diagonally, but in the direction of its flow. By these means it was considered that the following results might be obtained:—I. The prevention of further damage to the river bank. II. The formation of silt banks caused by the deposition of sand and particles of soil carried in suspension by the water, both up and down stream of the spurs. III. The diversion of the stream from its present course into its old channel by coaxing it into the cut made through its old bed, which cut would, as the present channel silted up, scour out and enlarge itself.

In India various rivers have been successfully treated in this manner, and in America, the use of brushwood for dams in connection with irrigation works is common amongst engineers. In this colony also, valuable work has been carried out with the use of brushwood, on the Moruya River and elsewhere, by Mr. Williams, Assistant Engineer of the Harbours and Rivers Department. But the practice does not obtain sufficiently, although we have such enormous quantities of ti-tree, pine, she-oak and other scrubs handy to most of our rivers. The method is cheap and effective, giving the very best results when properly carried out, and it is deserving of more attention at the hands of engineers. The spurs, suggested in the case of the Hunter River, might be constructed in various ways, but the method adopted as the best in connection with the River Oomla, in India, consists in driving into the bed of the river stout stakes or light piles, at distances of ten or twelve feet apart; these stakes should be securely stayed and anchored to prevent them from being swept away, and then connected by strong ropes or wires upon which brushwood or leafy branches of trees are to be fastened.

The author made some experiments with miniature spurs in a rapid mountain stream and obtained exactly the result he required, viz.:—A deposit of silt or sand, both up and down stream of the spurs, the greatest amount of deposit being at the shore ends, and diminishing gradually towards the centre of the stream, where considerable scour took place at the points of the spurs. The amount of scour and the deposits varied according to the angle formed by the spur with the direction of flow of the stream.

In different streams this angle would vary according to their velocities and depths; but without making a great number of experiments of a thoroughly practical nature, the ratio which the angle of a spur should bear to the velocity and depth of a stream, could not be determined. These spurs should not be built more than five or six feet above ordinary water level, as most of our rivers, after rising the heights mentioned, carry enormous quantities of timber and débris, which would accumulate against the spurs,

and carry them away. Another simple method of causing the deposition of silt is to dispense with the use of stakes, and, instead, fasten large branches of trees by ropes to wooden crates, filled with stones, which act as anchors. Many of these floating spurs were used by Mr. Tufnell, Assoc. M. Inst., C.E., on the river Tangri, in India, with most satisfactory results. In conclusion, the author only regrets that he cannot give account of practical experiments with works of this kind, which he is conscious of having but poorly described; he trusts, however, that the subject will evoke that amount of discussion amongst the Members of this Association which its importance warrants. He also trusts that the unavoidable plagiaristic tendency of his paper will be charitably overlooked, when it is considered that the subject has been already so ably dealt with by many writers with large and varied experience in works of the kind in other countries—especially the author may mention a a paper by Mr. C. F. Tufnell A.M.I.C.E.,* on "Economical River Training in India," to which he is indebted for a great amount of information on the subject which he has presumed to lay before you to-night.

* See Vol. LXXII. Minutes of Proceedings of the Institution of Civil Engineers.

DISCUSSION.

Mr. Shellshear said the subject under discussion was one of considerable importance to the colony, and he regretted Mr. Wells' unavoidable absence from the meeting. Under the circumstances, he considered all they could do was to move a vote of thanks to the author.

Mr. Henson, seconding the proposal, expressed the opinion that the subject dealt with in the paper was one of very great moment. They were only starting to deal practically with protective work of this kind in the colony. There were very large areas of land bordering our river sides, and as these lands became more valuable, people would evince more anxiety to provide against the destructive action of the river-water, as was the case now at West Maitland and elsewhere. Some cheap protective method was badly wanted. This was exemplified on the Hawkesbury River, where at certain parts the action of the river's flow was shown by the caving and falling in of the banks. Another illustration of the change which goes on where the course of river channels is not regulated could be observed by looking across the valley at Windsor.

Mr. Nicolle said that Mr. Booth, who had formerly been secretary of the Association, had written to him relative to the banks of the Suez Canal, and had ventured the opinion that iron sheathing should be used to protect the canal's banks. Such a system, however, did not commend itself. With regard to the measures advocated in the paper just read, he would point out that, while fascining work could be well applied in some instances, it would not do in parts where rivers were subject to heavy floods, as the fascining would be washed away.

Mr. Fischer pointed out the necessity for those using ti-tree for such work as that in question not to destroy the tree by

injudicious cutting, in order that the supply of that class of material might be allowed to remain sufficient for requirements. In Germany, France and other places, river channels had been successfully regulated by fascining.

Mr. Dickinson considered that Mr. Nicolle somewhat underestimated the usefulness of fascining work. He had seen work that had withstood many a flood. He was of opinion that settlers in the country districts should protect their own lands, and not fly to the Government at all times for assistance.

Mr. Haycraft considered that groins in the long straight stretches of rivers would be much preferable to fascining. As regarded the Suez Canal, there was no natural current in it, the action of the water on the banks being solely due to the disturbance caused by shipping. This was remedied by planting shrubs on the surface of banks. Relative to a reference made to France, it must be considered that that country was not subject to the periodical rains which occur in Australia.

The President suggested as a remedy to meet the requirements of districts where rivers overflow to a great extent, that canals should be cut to carry the water further into the country, where it was badly required for irrigation. To his mind, that was a question worthy of much consideration, inasmuch as it afforded a means of irrigation from the natural flow of the water. All protective works for river banks must depend greatly on local circumstances. He would commend to their attention a work by Stuart, on rivers and river banks.

8th May, 1890.

VAN RYSSELBERGHE'S HYDRO-DYNAMO SYSTEM OF ELECTRIC LIGHTING.

In the address which our worthy President delivered at the past March meeting of our Association, he drew attention to one of the principal questions of the day, viz., the substitution of electricity for gas for the lighting of cities. He showed us the great extent to which electric lighting is already applied, and the still greater extent to which it will be applied in the near future.

It is well known that some firms can hardly keep up with the demand for electric plant; one thing is certain, and that is, that those firms constructing electric machinery are making larger profits than the shareholders who have had the misfortune to invest in electric lighting companies.

Are there any of you gentlemen who could name a company that sells the electric light at the same price as gas, the said company being in a prosperous condition, and paying a reasonable dividend? This proves at once that there is something wrong in the present method of electric lighting.

Our President has, however, expressed the opinion that, notwithstanding the panic that took place in New York and elsewhere, there is no reason to apprehend any danger under the existing systems, and that there is nothing to prevent capitalists from investing in electric light companies. You will see from the substance of the paper to which the author now asks your attention, that if our President had gone a little deeper into the matter, he would probably have arrived at a slightly different conclusion.

Mons. F. Van Rysselberghe, the Belgian electrician, inventor of the system of simultaneous telegraphing and telephoning at long distances on the same wires, the system which connects Paris and Brussels, and many of the principal cities in Europe and America, but not yet adopted in this country of progress, has submitted to the Brussels Council, a system of his own, which the author will now endeavour to describe.

We all know that the gas companies could, if they chose, considerably reduce the price of gas to the consumer without in the least compromising their own interests. They might still pay very handsome dividends, while charging a much lower rate.

Supposing the gas companies reduced the price of gas to the extreme limit, what would then become of all the present electric companies? But the gas companies do not reduce the price of gas, simply because they see no such necessity yet; they are not yet afraid of the competition of the electric light, for the reason that existing electric light companies make little or no profit, while the greater number have already been forced to wind up their businesses.

If electric light has to be made a complete success, it must not only be sold at the same price as gas, but it must be produced at the same, or, better still, at a smaller cost, and the day that that is accomplished gas will have finished its career.

In the present paper the author proposes not only to show you that such a result can now be obtained, but also to prove to you the absurdity of the principles on which, at the present time, electric lighting is conducted.

On the 25th of March, of last year, the Municipal Council of Brussels called for tenders for "the establishment and working of an underground system of distribution of electricity for lighting the city, to supply motive power, and, if required, currents to be made use of for other purposes."

Electricity is only one particular form of energy. Heat, wind, running water, are so many forms of energy, susceptible of being transformed one into the other.

A distribution of electricity in a city, for the purpose of lighting, is at the same time a distribution of motive power. But, *vice versa*, a distribution of energy in the form of water under pressure or compressed air is also a distribution of electricity. Considering that they may be utilized for driving a dynamo, and by the aid of a suitable motor, the energy which has been mechanically distributed can be converted into electricity.

Which is now the mode of energy best adapted to be distributed on a large scale? That is the question.

M. Van Rysselberghe has treated it in a work called "*Théorie Elémentaire de l'Electricité et du Magnetisme*," published some time ago. The conclusion of this book is given in the following words:—"Certainly, all economical considerations being put aside, there is not a mode of energy more suitable to the requirements of a large distribution, than electricity. Nothing is easier than the erection of a copper wire, which, though of a comparatively small diameter, is able to convey to any place the electric current, and this through motors which are as simple as they are compact, can be transformed at will into heat, light, mechanical work, &c.

"It is not surprising that, at the time of the International Exhibition of Electricity in Paris, in 1881, when the practicability of the production and industrial utilization of electricity was demonstrated on such a large scale, that vast projects were formed and a total revolution was predicted in the art of lighting, heating, and power.

"The enthusiasm of the first hour even made some see the possibility of the utilization of the natural energies, such as wind, the tides, the rivers and waterfalls, of supplying the many requirements that progress and civilization have created in the large centres of population.

"I should be very pleased if I could encourage those hopes. But the scientific man, like the historian, owes himself to truth, or to what he believes to be the truth, above all else.

"*Electricity cannot be transported economically*. Facts have demonstrated the veracity of this conclusion.

"Up to the present gas has remained cheaper than electricity, except where the latter can be produced and consumed on the same spot.

"It is quite possible to create in the heart of a large city, where one can depend upon a large consumption within a small radius, a central station for the production of electricity, and so compete advantageously with gas from a purely economical point of view.

"But the future will not belong to central stations, the consumer having too great an interest in producing himself the electric energy that he may require.

"With our present knowledge, we have to give up the idea of a large central station, distributing the current direct, over a whole city at a reasonable rate: carrying to each house and to the most distant spots of a thickly populated city, the charm and the hygienic advantages of the electric light. We must also give up the expectation that every workshop and each small manufacturer will get his motive power from such central station.

"Referring to natural forces, if one could, for instance, utilise the work of a waterfall and distribute it over the whole of a city, I do not believe that the most economical way would be to transform on the spot this force into electric energy, and to distribute it in this form. It would be better to utilise the work of the waterfall in forcing water into accumulators, which would deliver it into pipes all over the city. Then for electric lighting one could erect a great number of small stations, where the dynamos would be worked by small water motors, each of which would supply the requirements within a small radius.

"The economical law for the transport of water under pressure, compressed air, or gases, is quite different from that of electricity.

"Water under pressure and compressed air can, like gas, be distributed economically over the whole surface of a large city. They are sources of motive power, and can as such produce electricity at the small consumer's home. It is in that direction that the innovators have to work. Let them simplify the gas

engines, let them produce perfect hydraulic or air motors of high efficiency; above all, let these motors require but little attention when working, and the problem of the economical distribution of energy will be solved, and at the same time the cheap production of electric light.

"In the United States, lighting by electricity is carried out to a much larger extent than in Europe. The cause is, that there they do not trouble themselves much about the cost of a thing so long as it is convenient and good. All progressive steps are always well received there. The cost being a secondary consideration.

"Electricity at high tension is transported comparatively cheaply, but it becomes dangerous for those manipulating the machines and the wires. In more than one American city, the tension of the current used is 4,000 volts, but it would be difficult to number the victims it has made.

"At 100 volts electricity is harmless; but its transmission becomes costly.

"Finally, as soon as the question arises of lighting not a single house or a single establishment, but part of a city by a central installation, the difficulty of maintaining a uniform electric pressure at every point, becomes extreme.

"In conclusion, the electric current, which in the genera opinion is so easily transported, is not transportable at all."

This is the conclusion arrived at by one of the ablest electricians of the day, and yet in face of it, our President in his last address gives the example of an American Company which intends to carry the electric current to a distance of no less than twelve miles before distributing it.

There are other sources of energy, which for purposes of transmission are far superior to electricity. Let us consider, for instance, water under pressure. Supposing the initial pressure to be fifty atmospheres, a tube of ten square centimetres section and in which the water would have a speed of one meter, represents in reality an energy of 500 kilogrammetres per second, which is equal to six-horse power.

The pipe necessary for this pressure costs, say a shilling a meter, the loss by friction is only four meters per kilometre or 1,000 meters, which is equal to the $\frac{8}{1000}$ of the 500 meters.

To transmit an electric current at 100 volts tension, the same quantity of energy, it would be necessary, in order to avoid heating, to use a copper conductor of $44^{\square mm}$ section. Such conductor, without counting the insulating material, would cost only ninepence or the $\frac{7}{10}$ of the price of the hydraulic pipe. But the loss by resistance would be 17 volts per 1,000 meters, that is to say 17 per cent. in a system at a hundred volts, while with water the loss is only 8 per cent., a marked difference In other words, the efficiency of water under pressure is twenty times greater than electricity.

For the loss by resistance of the copper conductor to only equal $\frac{8}{1000}$ of the original current, as is the case with the water, it ought not to offer more than 0.02 ohm. resistance per 1,000 metres, which would necessitate a section of 800 square milimetres. But then the conductor would cost twelve shillings per meter, that is to say *twelve* times more than the hydraulic pipe.

The physical law is as follows :—

The transmitting capacity of hydraulic pipes increases according to the *fifth* power of the radius; while the conductability of electric cables increases only according to the *square*.

Further, we need not fear, that water, at a pressure of 50 atmospheres, presents any danger. With compressed air or steam it would be dangerous, owing to the expansion of air and steam. But water is almost incompressible; it never causes explosions because there is no expansion. When we submit a tube filled with water to increasing pressure, in order to burst it, everything goes as quietly as possible : the tube bursts and the water escapes, but no damage is done. A jet of water has very little projective power, owing mainly to the great pressure the water is shattered, and after leaving the tube at a yard's distance is reduced to spray.

The tubes to which reference is made as costing a shilling a meter have a bursting strength of over 300 atmospheres; they

are tested to 180, and, considering they are worked only at 50 atmospheres, the security is perfect.

Hydraulic power of this kind has been in existence for a long time in all the large seaports, especially in Antwerp, and every detail of the system has received the sanction of every day practice.

To produce electric light by water power, a dynamo coupled with a hydraulic motor is required. Hydraulic motors are simple, do not require any looking after, and can be left to themselves. Although of small size, they possess considerable power; and to set them in motion or stop them, only a cock has to be opened or closed, which can be done by the most ignorant or unskilled person.

In a word, the hydraulic motor can be made simpler than the simplest gas meter, and M. Van Rysselberghe lays great stress on the point that it requires no care nor looking after. Up to the present, however, there are no hydraulic motors of high efficiency working at high pressures. M. Van Rysselberghe has made a special study of this question, and has designed a motor which meets all requirements. With this new machine, electricity can be produced under such advantageous conditions that the electric light has the advantage over gas, not only for elegance, hygiene, and comfort, but also from an economical point of view.

The scheme which M. Van Rysselberghe has formed for the electric lighting of the city of Brussels, and which would apply equally well to Sydney or any city, can be described in a few lines. He proposes to erect as near the city as possible, on a spot where land is cheap, near the River Seine, hydraulic pumps, similar to those used in Antwerp for the services of the wharves and docks; and pump the water out of the river, and force it into accumulators. Cast iron pipes would be laid from the accumulators all over the city, and the water would be available as motive power for small industries.

For the interior lighting of buildings and private houses, a hydro-electric apparatus would be erected. When light is required, it will only be necessary to open the cocks just as at present one opens the cock of the gas meter, and thus the electric light will be produced at once.

For the lighting of the streets at a certain number of points, these same hydro-electric machines, relatively powerful, but always of small dimensions, and each supplying a zone of restricted size will be erected. These would be small stations producing electricity, but unembarrassed by all the cumbersome steam boilers, engines, and numerous staff which renders so difficult and costly the establishment of ordinary electric stations. The author thinks it will interest you to know that a hydro-electric machine of 500 horse-power, of the model adopted by his countrymen can be erected on an area of 6 ft. 8 in. square. The water after having been used would run into the gutters or sewers, which would thus be constantly cleansed, which is an important item from a hygienic point of view, especially in a hot and sometimes very dry climate like that of Australia.

Another consideration is that in our democratic Australian cities we must avoid a public service or benefit being of advantage in only some privileged quarters. Should the city of Sydney establish a service of electric lighting on the scheme he proposes, the taxpayer of a remote street would have the same advantage as any inhabitant of a principal thoroughfare. Though this desideratum can be obtained with M. Van Rysselberghe's scheme, it is very doubtful if it could be attained by a direct distribution of electricity.

M. Van Rysselberghe stated before the Municipal Council of Brussels :—" The working of the Central Electric Station, by the present methods returns to the shareholders of the best organised and most flourishing companies only a dividend of five per cent.

" Those central stations, as at Berlin, sell the electric light at 5 centimes per lamp per hour, and give 5 per cent. dividend.

" I am convinced, and I am ready to prove it at my own risk, that I can supply the same light for $3\frac{1}{2}$ centimes, and make a profit of 100 per cent.

" Do you believe me ? If so, undertake the thing on your own account, and keep all the profit for the municipality. Are you not sufficiently convinced ? Are you afraid of embarking in

the venture? If so, give me the concession, capitalists are ready to support me, and if I succeed you can take over the whole concern."

You see from this that if ever an inventor did believe in his invention it is M. Van Rysselberghe.

But it is not enough to *advance* these facts; they have to be proved. Why has electricity not kept the beautiful promises that were made in its name after the Paris Exhibition of 1881? Simply because its practical transport, in large quantities, for the requirements of public lighting, necessitate wires of pure copper of colossal size, and pure copper costs over a shilling a pound. Up to the present the whole question lies there. The difficulty is of a purely financial order: copper is too expensive, but there are no technical difficulties.

What is required for an incandescent lamp to burn and be preserved? Only one thing; that is, that it be submitted to a regular and constant electric pressure. This pressure is measured in "volts." The usual lamp is constructed for 100 volts; if it is supplied with a current at 98 volts it furnishes very little light; if it receives 104 volts, it does not last, it soon flies into fragments, as would an overworked steam boiler. A constant electric pressure is absolutely necessary.

A similar condition is necessary for a distribution of gas, the pressure must be uniform in the whole length of the pipes, and above all, *the pressure should remain uniform, whatever may be at a certain moment the amount of the consumption.* To obtain this regularity of pressure, the resistance of the pipes should be reduced to nothing.

People are sometimes surprised at the size of pipes put in the ground for distributing gas over the city. These pipes seem to be of an extravagant size when it is thought that they have only to carry so subtile a fluid, lighter than air. Why these enormous pipes? they say. Simply to reduce to almost nothing the resistance that their surface might offer to the motion of the gas; in other words, to render the pressure uniform and assure the mutual independence of all the lights.

The same should be done with electricity. The resistance of the wires has to be reduced to an unquotable quantity; then the service would be simple and practical—as simple for electric light as for gas, for the requisite conditions would be identical in both cases. But reducing the resistance in an electric reticulation to an unquotable quantity practically *nil*, is not to be thought of, for copper is too expensive. Take for example the lighting 10,000 lamps, placed at 1,000 meters from the central station, by direct distribution at 100 volts, and admitting even five per cent. loss, which quantity, however, ought not to be neglected in practice, as we should not tolerate more than one per cent. But even if the loss is five per cent. it would require pure copper bars of 20 centimetres square. This would represent 720,000 kilogrammes of copper (or 720 tons) at 2s., say £72,000 worth of copper, and which only represents the value of the copper. If we now consider that the wires have to be insulated very carefully, and that the insulation costs at least as much as the copper, that would represent £144,000 buried in the ground with the aggravating consideration that up to the present we are not at all certain about the durability of copper cables for electric lighting.

At Berlin they have thus placed £100,000 worth of cables, which, after three years service, have failed.

Professor Forbes, who, like M. Van Rysselburghe, has studied the principal electric stations in Europe and in the United States (in the Journal of the Institution of Electrical Engineers, of 1889, No. 78, page 188) states as follows:—

"We have now to consider a very important and perhaps the most difficult part of the problem of lighting by central stations: how to preserve the insulation? . . . During late years one has much praised a kind of cable to which I wish to refer. The copper conductor, twisted or not, is covered with a fibrous material, preferably hemp, impregnated with bituminous oil, and then enclosed into lead tube. In this kind of cable the insulation depends upon the impermeability of the lead.

"We all know that cables of that kind have rendered good service, for a limited time, and many of us were tempted to

believe that they were very satisfactory. But I think I am right in saying that none of us has any knowledge of those cables having successfully worked anywhere for more than three or four years."

The author thinks that in view of the opinion expressed by such an authority as Professor Forbes, it would not be rash to propose for the city of Sydney a system which does away with cables and the extravagant expenses connected therewith; but it would be extremely rash to follow the old track, the future of which is so very uncertain. Some may say that we can use other cables, insulated, for instance, with gutta-percha, costing only from 12 to 15 francs per kilo. That is true, but gutta percha, the best insulator known, only retains its condition when completely under water.

There are a great number of ways of obtaining a good insulation; for instance, by increasing the thickness and number of rubber coverings, and enclosing the cables in cast-iron or stone-ware pipes, etc. There is no practical difficulty, but there is always the important question of cost. To obtain by electricity as simple and practical a service as with gas, the electric resistance of the cables ought to be reduced to an unquotable quantity, but this cannot be thought of on account of copper and india-rubber being too expensive.

What is being done under the circumstances?

This: They have recourse to expedients and artifice. First of all they light the best part of the city, the portion where large consumers are close together, and the other quarters are left alone until better times. After that, not being able to establish the stations in distant places from the centre, where land could be purchased at reasonable prices, and where all the necessary space could be obtained for a good and practical installation, but being obliged to erect electric batteries and steam engines of several thousands of horse-power on very valuable land, where, for want of room, they put the engines one on top of the other, going sometimes as far as superposing two stories of steam boilers, as has been done in New York. Or they excavate the ground and get under the river beds, where the men get half smothered in underground galleries, and also run the risk of blowing up everything above.

Imagine erecting steam boilers of many thousands horse power in the very heart of the city! This is the point we are reaching, and logically so, for on account of the expense there would be no chance of doing otherwise.

And this is not all; for being obliged, notwithstanding the practical insufficiency of the cables to maintain a uniform electrical pressure at every point of consumption, they are forced to constantly modify the run of the dynamos, according to the variations of the consumption. Intelligent, careful, and experienced men succeed in performing even that feat, but is it a merit to be placed to the credit of the system?

What would the Chief Engineer of the gasworks say if he were told by the Board of Directors: We are going to remove the gasworks and alter the pipes in the city. These pipes will be reduced to one quarter of their present diameter. In reference to space, it will have to be strictly limited to the requirements of the gas-holders. You must put the retorts on the second floor, above the gas-holders; all the rest of the plant on the third floor, and you must store the coke where you can manage it. The gentleman referred to would probably succeed in building up such extraordinary gasworks as pictured, but surely he would never show them as an example to be followed.

But again, what is absurd in one case beomes logical when the question arises of the establishment of a central electric station according to the present practice. Electricity consumed on the spot where it is produced is a cheaper light than gas; but its transmission to a distance is costly. If such affirmation required proving he would give as an example the North Railway Station in Brussels, where the substitution of electricity for gas has resulted in a considerable economy to the Belgian Government.

Unfortunately, owing to the important and expensive machinery required, it is only large consumers who can afford to produce the electric light themselves. But we have the high pressure water motors. We have the Barker's Mill, which is very simple in construction, and requires but little attention when working. Let us apply it direct to the axle of a dynamo and open the watercock,

and the current is at once generated. There are, of course, some important details. For instance, it is necessary to admit the water through the axle, through a water-tight joint, without there being detrimental wear. Above all, and this is the important point, the motor has to revolve at a uniform speed, whatever may be the variations of the hydraulic pressure or of the consumption of light. But those conditions being obtained, as there are dynamos furnishing a constant electric pressure, whatever may be the number of lights, provided only that the speed be uniform, one will arrive in a very simple way at this result—so difficult to obtain with a direct distribution of electricity, that each consumer will be independent of all the others. This uniformity in the speed, in spite of the fluctuation of the hydraulic pressure, and the variable quantity of light consumed, seems to be at first sight, an enormous difficulty. But M. Van Rysselberghe says it is a repetition of the story of Columbus and the egg—he has found the simple and elementary solution.

There is another objection which is met in the same manner: —"If the joint of a large pipe breaks, everything is stopped." Not so, everything is not stopped; there is only a small section momentarily out of service. The reticulation is double, and in sections. If a joint bursts (the accident seldom happens, but has to be foreseen) two valves are shut automatically, and the escape is instantaneously stopped. Now the question arises, at what price can the water power be furnished, and at what cost to the consumer can the light be produced by this method? It is to be noted that here we have positive bases to calculate upon, known for long, and sanctioned by a practical experience of more than a quarter of a century.

A power distribution by water at 50 atmospheres has existed for over twenty-five years in London, and it covers to-day the whole surface of the immense metropolis. A similar distribution has existed in Antwerp for about ten years, and works to the satisfaction of all. It is known by experience what are the practical diameters and thicknesses of metal required for an hydraulic reticulation of this description; their cost is known, and what is very important, it is

also known that the hydraulic pipes, contrary to electric cables, remain undamaged in the ground.

In Brussels—and it would not be much higher in Sydney—the cost of water at pressure of 50 atmospheres would be 17½ centimes per cubic meter; it is proposed to sell at 35—which represents a profit of 100 per cent. for the company.

The conclusion to be drawn from this is that if the lighting of the city with M. Van Rysselberghe's scheme were undertaken by the municipality it would be for them a source of important revenue. The sale price of 35 centimes per cubic meter being adopted, what would be the cost of the electric light to the consumer? It can be calculated as follows :—

The duty of the hydraulic motor being put down at the small minimum of 50 per cent., M. Van Rysselberghe has made the following calculations for consumers in Brussels :—

He takes first the case of a small installation of 20 lamps of 50 watts each, and calculates on an average of four hours a day lighting :—

Cost of Plant.

	Francs.
Hydro-dynamo machine of 2,000 watts (equal to 40 lamps)	1,500
Erection	400
Measuring instruments, &c.	400
Capital	2,300

Annual Expenses.

	Francs.
Interest and sinking fund of ten per cent. ...	230
Rent of water meter	50
2,000 metres of water, at 35 centimes	700
Miscellaneous	20
	1,000

Or 50 francs per lamp for 1,460 hours of lighting, or 3½ centimes per lamp and per hour, which is in Brussels the price of gas, with an equivalent profit to the producer.

Supposing, now, an installation of some importance, say 100 lamps of 50 watts :—

Cost of Plant.

	Francs.
Hydro-electro machine of 6,000 watts (equal to 120 lamps)	3,000
Erection	500
Measuring instruments, &c.	500
Capital	4,000

Annual Expenses.

	Francs.
Interest and redemption fund, ten per cent. ...	400
Rent of water meter	50
10,000 metres at 0·35fr.	3,500
Miscellaneous	50
Total	4,000

Or 40fr. per lamp, and for 1,460 hours of lighting, or $2\frac{3}{4}$ centimes per hour per lamp. This is much cheaper than gas, and yet it leaves a profit of 100 per cent. to the producer.

Is there now any doubt about the cost of water power at 50 atmospheres which M. Van Rysselberghe says would be $17\frac{1}{2}$ c.m. Brussels? Ten years' experience in Antwerp has shown that a cubic meter can be delivered at a pressure of 50 atmospheres at a cost of eight centimes for coal, oil and grease.

Does a yield of 50 per cent. for the hydraulic motor seem too high? We all know that very often they reach 85 per cent.

Only one other doubt may still exist in your minds, that is, with regard to the value of Mons. Van Rysselberghe's hydraulic motor. The method proposed for the general lighting of a city ensures the hydro-electric machine being simple and trustworthy enough to be left to itself like a gas meter, in the care of anyone, who will only be required to open or close the cock, leaving, if so desired, to the care of the company, the occasional inspection of the dynamo.

The author wishes to mention that M. Van Rysselberghe's hydro-electric machines have been in practical use for several months in Antwerp, and that before long the greatest part of the city of Brussels will be lighted on the same principle. Again, with this system it is presumed that every important consumer will have his own hydro-electric machine, but for the lighting of the streets, and the large number of private houses where they will not care to go in for the purchase of the machine, local stations of moderate importance would be established in a cellar or yard. Each station would be composed of a series of accumulators which would be charged during the day by the hydro-electric machine, and this station would distribute, within a small radius, the electric energy to consumers of less importance. These latter consumers would, of course, be charged at slightly higher rates.

The author, during his recent stay in Europe, has had the opportunity of discussing this important and interesting question, not only with M. Van Rysselberghe himself, but with many engineers possessing the highest qualifications and repute on the subject, and in their minds there seems to remain no doubt whatever as to the truth and practicability of the scheme advocated. All are agreed that, thanks to M. Van Rysselberghe, electric light can be now produced cheaper than gas, and that the question of the general lighting of cities and private houses is solved.

There are at the present moment several Australian Municipal Councils about to adopt the electric light on the old principle, the absurdity of which, the author hopes, he has proved. And he trusts that when the report of this meeting shall have reached them, they will for the sake of their Municipal finances, pause, and make no hasty decision, at least until full inquiries have been made as to the merits of the system he has had the honor to introduce and advocate. One thing is certain : Everything that may be done on the old principles will have to be undone.

DISCUSSION.

Mr. G. Fischer stated that he had been requested by the President to open the discussion, it afforded him pleasure in moving that a vote of thanks be accorded to the author of the paper, for, although he did not at all agree with Mr. Van de Velde's conclusions, he deserved the thanks of our Association on account of his paper forming a basis on which a discussion can be started on this most important question of electric lighting. The contents of the paper might, for the purposes of discussion, be shortly summarised under two headings, viz: 1. That the distribution of an electric current at a higher tension than 100 volts is not only dangerous to living beings, but is absolutely impracticable, for does he not come to the remarkable conclusion in the following words: — "In conclusion, the electric current, which in the general opinion is so easily transported, is not transportable at all." In the second part of the paper, Mr. Van de Velde attempts to demonstrate that the only feasible way to admit of every inhabitant of a city partaking of the benefits of the electric light is by means of a high pressure water service, generating the electric current on the consumer's premises. To refute in detail all the statements made would take as much, if not more time, than the reading of the original communication. He should, therefore, content himself with quoting, in answer to the first part of the paper, the opinions of some of the most eminent authorities of the present day. On reference to the *Electrical Engineer* of April 2, 1890, p. 176, you will find certain answers in reply to questions issued by the New York Senate Committee, relating to the practicability and safety of underground high tension circuit; they are as follows:

Q. 1.—Can high tension, direct and alternating, currents for lighting and power purposes be safely and successfully distributed

by means of underground cables? If so, up to what voltage can this be done?

Sir William Thompson: Yes, I believe so, up to 2,500 volts.

Professor George Forbes: We have ample proof that high-pressure electric currents, either direct, or alternating, can be distributed safely and successfully for lighting purposes, by means of underground cables. Our experience in the past has been limited to 2,500 volts, as a maximum.

Dr. John Hopkinson: It has been conclusively proved that alternating high-tension currents can be supplied without inconvenience, by means of underground conductors, if the work is properly done; it has also been proved that this can be done with a potential of 2,400 volts.

Mr. W. H. Preece: I see no difficulty, whatever, in maintaining such a system of distributing currents by underground cables, and I form that opinion from actual experience, and not from mere theory. Underground cables are safe, durable and efficient. I have had full experience of a high pressure alternating current system in Eastbourne, where such a system, working with a voltage of 1,800 volts, has been at work since 1886, without a single accident or failure, and is now feeding 2,600 lamps. A similar system, of which I have had similar experience, has been applied in London at the West Brompton Central station; 1,800 volts have been distributed for over twelve months, through sixteen miles of underground wire for lighting purposes throughout the rich and flourishing neighbourhood of Kensington, without a single failure.

Mr. E. Fresquet: Direct and alternating currents of high-tension, for lighting and power, can safely and successfully be distributed by means of underground cables, provided ordinary precautions, known to all electricians, are taken. In my own experience I have used 3,000 volts.

Q. 4.—What is your opinion as to the safety of the consumer and the public at large, of the converter or transformer system of electric lighting, involving the use of high-tension alternating currents in the street main?

Sir William Thompson: With properly laid mains the high-tension alternating currents in the street mains underground, involve, I believe, no danger whatever to the public at large. The converter, or transformer system, can, I believe, be made absolutely safe to the consumers by proper arrangements. It has already been largely practised in London, Glasgow and elsewhere, and, as far as I know, no instance has occurred of any consumer having met with an accident.

Professor John Forbes: After the alternating current transformer system had been proved to be efficient, it was accepted as the required solution of the difficulty, because the house-wiring is, on this system, completely separated from the street mains. Everyone in this country who then came to this conclusion, and has had experience of the system, has been confirmed in his belief that the transformer secured the required safety.

Dr. John Hopkinson: There is, in my opinion, no reason whatever, why high tension alternating currents should not be used in the street mains.

Mr. W. H. Preece: I have advised the Metropolitan Electric Supply Company of London to adopt the same system, and they are doing so, and I have also advised several local authorities in England to do the same thing, and they are going to do it. I do not express my opinion lightly on this subject. There are about 30,000 miles of underground insulated wire of the United Kingdom under my control, and I have had thirty-seven years' experience of such wires. I venture to think that this experience is unique in its continuity and extent.

Mr. E. Fresquet: The converter or transformer system, involving the use of high tension alternating currents, can be used with absolute safety to the consumer and the public at large. No accident can happen if well-known precautions are taken, and the neglect of them implies great ignorance.

He had only given a few short abstracts of this valuable evidence, but he was satisfied that the opinions advanced by such authorities as Sir William Thomson, Professor George Forbes, Dr. John Hopkinson, Mr. W. H. Preece, and Mr. E. Fresquet would

convince any unprejudiced and disinterested person, that the statements made by Mr. Van de Velde regarding the distribution of electricity at higher tension than 100 volts were, to put it mildly, erroneous. Let us now go on to the second part of the paper, and for convenience and brevity's sake assume that M. Van Rysselberghe's Hydro-Dynamo is an established mechanical success; consequently the matter is narrowed then to the question of £ s. d., or to put it in plain language, is it cheaper to light a city with the electric light by means of the Van Rysselberghe system than by a perfectly safe system of high tension alternating currents, converted to low tension before entering the consumer's premises? He feared M. Van de Velde's figures at the end of the paper were of very little practical value, as for example in the case of Sydney, instead of the Hydraulic Power Company being able to sell the water at about 1s. 3d. per 1,000 gallons (equal to thirty-five centimes per cubic meter) as in Brussels, they would have to pay 1s. 6d. per 1000 to the Water and Sewerage Board in the first instance, which would more than double the price quoted, quite regardless of all the other items tending to increase the cost of production over that said to exist in Brussels.

However, the comparative cost could be ascertained in a different manner. The distribution of electricity could be utilized for either lighting or power purposes, and in Mr. Gisbert Kapp's book on "Electric Transmission of Energy," p. 234, you will find a table giving the "price in pence of one horse-power hour obtained at the receiving station." This table was based on averages obtaining on the continent of Europe and Great Britain, and compared the cost of electric, hydraulic, pneumatic and wire-rope transmission of energy; the two first only interest us here. We will assume that we want to light 1,000 16 c.p. lamps at an average distance of 1,000 meters from the generating station. To do this it would take in round numbers 100 horse power for the electric system, which would cost 1·91 pence per horse-power hour, or about 16s. per hour for 1,000 lights; for the hydraulic system we should require just about double or 206 horse-power, as we could hardly rely on obtaining more than 50 per cent. of the

original power supplied out of a number of small hydro-dynamos, which at 1·78 pence per hour would give for the 1,000 lamps about 30s. as against 16s. by alternating current distribution, which was about 47 per cent. in favour of the latter. Of course these figures would not apply to Sydney, but they were reasonably correct for purposes of comparison. He (Mr. Fischer) thought it might be fairly claimed to have been demonstrated that, to enable us all to enjoy the undoubted blessings which the electric light confers on modern society, it would be necessary for us to cast about and select a different system to the one described by Mr. Van de Velde.

Mr. Norman Selfe said: Mr. C. Van de Velde's paper was entitled "Van Rysselberghe's Hydro-Dynamo System of Electric Lighting," but after careful reading he was bound to confess he was as far off as ever from knowing in what Mr. Van Rysselberghe's system consisted, and what were the improvements which that gentleman had introduced. The paper was of considerable length, was very discursive, and at the same time while it abounded in platitudes it contained a number of statements with which he (Mr. Selfe) felt sure many members of the institution would join issue. There were, however, in it three main propositions, and to these he would shortly refer.

Firstly, he was quite disposed to agree with the assumption that Electric Lighting could not at present be economically and safely carried out by the distribution of the current from a central station *over a very wide and scattered district;* because the fearful accidents that had occurred with high tension currents in New York and elsewhere, had prejudiced the public mind against such heavy pressures of electricity as were there used being allowed in the streets either underground or overhead; and the amount of copper required for voltages, as low as 100, effectively precluded their use over long distances. At the same time it must be borne in mind that the greatest Electric Light Station in the world—at Deptford, England—was preparing to send out currents of 10,000 volt power, and if the annular conductor that had been invented for that great distribution possessed half the qualities claimed for it, such extreme electrical pressures might yet become common.

On the second proposition of the paper that it was better to generate the power at a central station and transmit it by hydraulic pressure or compressed air to secondary stations where such power was transformed into electric currents for distribution, could not by any means be considered Mr. Van Rysselberghe's system. He (Mr. Selfe) had read papers before this association in March, 1886, and September, 1889, in which he had referred to the Hydraulic and other Power Companies, and had advocated the distribution of power by compressed air; he had also made special reference to the driving of dynamos for the electric light by such powers, citing the "Popp" System now so successfully working in Paris. The question of driving dynamos by water engines from the mains of Hydraulic Power Companies had not only been discussed for years back, but had been in actual operation. Mr. Van Rysselberghe's system must, therefore, consist in some details of the Hydro-Dynamo, which Mr. Van de Velde had, he presumed, inadvertently omitted to give the particulars of in his paper; in fact it was a "performance of Hamlet with Hamlet himself left out."

The third and most important portion of Mr. Van de Velde's paper was contained in the statements that Mr. Van Rysselberghe had made a special study of the question of hydraulic motors, and had designed a hydro-dynamo which would give a uniform speed "in spite of the fluctuation of the hydraulic pressure, and the variable quantity of the light consumed;" in fact, the invention was, Mr. Van de Velde said, a case of Columbus and the egg over again. Mr. Van Rysselberghe "has found the simple and elementary solution of the problem," but the solution was not given, a statement which sounded very well. Further, Mr. Van Rysselberghe, it was said, could supply hydraulic power in Brussels under a pressure equal to 50 atmospheres, for 35 centimes per cubic metre, and get 100 per cent. profit, as the power cost him only $17\frac{1}{2}$ centimes a cube metre; and, lastly, that Mr. Van de Velde was prepared to supply the light here in Sydney on the same basis for $3\frac{1}{3}$ centimes per light per hour, and make a profit of 100 per cent.

It would be interesting to the members of the Association to know in what way Mr. Van Rysselberghe had succeeded in obtaining a hydro-motor to keep uniform speed under variable pressure and work, because it was obviously much more difficult to do so with a non-expansible medium like water than it was with steam or compressed air, and it might be done with engines of variable stroke as made in England, but the author had said *nothing* about this.

With regard to the supply of water in Brussels at 50 atmospheres pressure for 17½ centimes per cubic metre, and in Sydney on the same basis, this, it must be noted, was 1·75 pence for, say, 220 gallons, or within a minute fraction of 8d. per thousand gallons. Now, as was well known, in Sydney the water alone costs 1s. 6d. per thousand gallons, so that if Mr. Van de Velde sold it at 35 centimes, or 3½d. per cubic metre, or 1s. 4d. a thousand gallons, instead of making 100 per cent. profit, as he stated he would, it appeared really that he would be making 2d. a thousand gallons loss, even if he got somebody to lay the mains and do all his pumping for nothing. The real fact was, the Hydraulic Power Company of Sydney was empowered by Act of Parliament to charge 12s. 6d. per thousand gallons, and if it reduced the price to the Melbourne rates to encourage custom, as explained by Mr. Swinbourne, the Melbourne company's engineer, in this room recently, the cost of water would then be 8s. a thousand gallons instead of 8d. Under these circumstances, and until these great discrepancies were explained away, it appeared useless to carry the investigation further, and compare the rates of 3½ centimes per hour, which Mr. Van de Velde proposed to charge for the electric lamps, to see if such rates would yield him 100 per cent. profit, as he stated.

In the statement made in the paper that the capacity of a hydraulic tube increases as the *fifth* power of the radius, there was probably some clerical error—it was certainly not correct.

Mr. Selfe, in conclusion, expressed a hope that the author in his reply would give particulars of it, and would state with regard to the calculations presented in the paper.

1. The efficiency of the main steam engines in lbs. of coal per horse-power per hour.

2. The cost of pumping per 1,000 gallons (to 50 atmospheres) pressure.

3. The cost of the hydraulic mains per mile and size per hundred horse-power to be transmitted.

4. Loss by friction per mile in pressure, etc. When such data was before it, this meeting would have something to discuss.

Mr. Fitzmaurice remarked that not having a great deal of leisure time at his disposal, he had not been able to give the subject the attention which was necessary, but it was one which should interest, not only the electrical and engineering community, but the general public.

Electric Lighting had made enormous strides during the last few years, and the demand for electricity in all its phases, and particularly as a lighting medium, was increasing at a wonderful rate. Even in New South Wales alone the progress was very marked, for in the year 1883 the number of incandescent lamps in use could be counted in hundreds, while at the present time the number exceeded 15,000, and large orders for more, notably the Centennial Hall (1,500 incandescent and 16 arc) the Australia Hotel and others were in hand. It could not be denied that a great deal of danger existed if high tension currents were used and proper supervision was not given in the erection of the wires, for in New York overhead electric lighting had been carried out to such an extent, and without regard to safety, that the authorities had been compelled to use the pruning knife to all overhead wires, and compelled the companies to carry them underground.

In cities such as Sydney, the cost of making conduits and laying cables would necessarily be very expensive owing to the network of gas and water pipes.

In underground conduits the greatest source of danger the electrical engineer had to contend against was gas and water, for owing to leaky mains gas had escaped into the subways, had frequently caused explosions, although at the same time the cause of ignition had not always been definitely proved, yet it had

invariably been charged to leaks in the electric cables. Some short time back a violent explosion took place in the Devonshire Street sewer considerably damaging the road; the cause (if his memory served him correctly) was assigned to the refuse from the railway gas plant finding its way into the sewer, but in this case there was no electric spark to cause ignition, so it was put down to spontaneous combustion. If such was the case, was it not likely that the explosions in the electrical subways were caused by the same agent? As long as faulty gas mains existed, so would also the dangers to subways exist, unless ventilation by forced air was resorted to, which meant additional expense. Water, on the other hand, was a dangerous enemy owing to its conductivity, and by coming in contact with cables destroyed the insulation and eventually grounded the circuit, making it extremely dangerous to handle if the current be of high tension, at the same time increasing the load on dynamo. Notwithstanding all these obstacles electric lighting was making tremendous strides all over the civilised world, and if we weighed up the number of accidents caused by its use it would show a very low percentage comparing with gas or kerosene. Gas and kerosene being very old friends of the public, very little notice was taken of explosions by either.

Mr. Van de Velde in his opening remarks made reference to the Gas Companies being able to reduce the price of gas considerably without compromising their own interest. But he (the speaker) considered that it was due to the rapid strides made in electric lighting that had reduced the price of gas to its present rate, for it was only a few years back when the price was just double. If electric lighting did not affect the profits on gas shares, it certainly excited the minds of the shareholders. (The late meeting to protest against the introduction of electric lighting in Newcastle to wit).

Mr. Van de Velde in making comparisons between the rival system of distributing mains, had taken an extremely low potential for central station electric lighting, and one which would never be attempted in Sydney; it was quite unnecessary for him to quote figures at that potential. Increase the voltage by 10 times, the loss of energy in transmission would be decreased by that ratio—that was

to say, supposing in a 100 volt circuit the loss of energy be 85 per cent. per 1,000 feet of conductor, only 85 per cent. would be lost by increasing the potential to 1,000 volts, for it could be seen at a glance that a plant of 10,000 50 watt lamps of 100 volts would require a cable sufficiently large to carry a current of 5,000 amps, whereas with a 1,000 volts, to obtain the same number of watts, would only require a cable of 500 amps capacity. So that allowing a cable of 1,000 amps capacity would only = 1 square inch in area, weighing 1·7 tons per 1,000 feet or about $5\frac{1}{2}$ tons per 1,000 meters, or, with double leads, 11 tons per 1,000 meters; and taking Mr. Van de Velde's price of copper, viz., 2s, would equal say £10,000, this showed a decrease of £60,000 according to estimate given in the paper in cost of cables for the same number of watts. He considered that a pressure of 1,000 volts was perfectly safe for underground circuits if carried out under proper conditions, but any considerable increase over that was undoubtedly troublesome and dangerous owing to the causes previously pointed out. If, as the author of the paper asserted, the future did not belong to central stations, the greater was the reason why this paper should be studied. By a system of hydraulic motors in working dynamos, the danger by high tension currents would be considerably reduced, if not totally so, but it was a very questionable matter as to the consumers' interest in producing the electric light himself. One great objection was the care required in keeping the dynamo in thorough working order and free from sparking. He was afraid this would be the chief stumbling block in the introduction of this system. For business houses, offices, etc., this system should work admirably, for there would be a considerable economy in space where private lifts or lighting were concerned. The one motive power would supply three very great commodities, viz., light, lifts, and safety from fire, for with a pressure of 50 atmospheres fire engines could be dispensed with. Moreover it would do away with the noise of engines and dispense with skilled labour, which seemed to be the aim of all inventions.

The cost of laying the water-mains would naturally be much less than cables, as the same care was not necessary in the one

as the other, and there would be no danger of explosion, shocks, or leaks.

In making out the cost of erection and maintenance, Mr. Van de Velde had not been very precise, for the cost of erection, measuring instruments, etc.; also, the price of water appeared very low. Did the cost of plant include the lamps, sockets, and wire, etc.? and did the sinking fund allow for renewal of lamps every year? If not, there would be a very considerable increase on the 230 francs.

Would it be possible in Sydney, where fresh water was sometimes a scarce commodity, and in view of the distance that an Hydraulic Company would have to go to pump water from a fresh water river, would it be possible to sell it to customers at the price quoted, viz., 35 centimes per meter, which was equivalent to 1s. 4d. per 1,000 gallons, when the Sydney public had to pay 1s. 6d. per 1,000 gallons, and yet did not return any profits? The price of water in this system would be the principal item to consider in adopting it.

If the prices given were correct, there would, indeed, be a great future in this system of lighting, for, in the case of the 1000 watt plant (20 lamps), the cost was only 6½d. for Board of Trade unit, or equivalent to gas at 3s. 7d. per 1,000. In the 5,000 watt plant (100 lamps) the cost was only 5.2d per B.T. unit or = gas at 3s. per 1,000. To compete with this only, an overhead system of cables could do it, but in a crowded city this would not be tolerated.

It would not be verging from the subject to mention that at the Jenolan Caves, the natural fall from the outlet of the underground river was being made use of for working an 8¾ Leffel turbine for driving a 6,000 watt dynamo for lighting the interior of the caves. This turbine at the trial worked admirably, not a variation in the voltage being noticeable during many hours' run; the fall or head of water was 45ft.

Before concluding, he would like to draw attention to the cost, etc., of working the Circular Quay, Cowper's Wharf and Post Office.

Circular Quay.—At the Circular Quay they had a Fowler's 20 h.p. nominal semi-portable compound engine (non-condensing) 3 No. 7 Brush dynamos (1 spare). Two of these were coupled up in series to feed 28 Brush lamps. The total voltage was between 1,300 and 1,400, and there had not been a single accident to any human being; but there had been a few accidents to the lamps through drays running into the poles. The cost per annum was as follows:—

28 Arc Lights	Coal at 14s. 6d. per ton ...	£187	17	7
	Wages...	369	0	0
	Stores and repairs	182	12	0
	Water at 1s. 6d. per 1,000 gal.	11	11	3
	Cartage	2	14	4
	Total	£753	15	2

The lamps were worked for 3,804 hours per year, which, multiplied by 28, the number of lamps = 106,512 Lp. hours

$\therefore \frac{£753\ 15s.\ 2d.}{106,512\ \text{Lp.h.}}$ = 1.7d., nearly, per lamp per hour, each lamp = 500 watts, nearly, therefore the price for Board of Trade unit was 3.4d., which was equivalent to gas at 1s. 11d. per 1,000ft. This estimate did not include depreciation or interest on plant; however, allowing 10 per cent. on £3,000 (value of plant) for interest and depreciation, it would only increase the cost to 4.8d. per B.T. unit, which was equivalent to gas at 2s. 9d. per 1,000 feet. This and Cowper's Wharf installation had overhead wires.

Cowper's Wharf.—Cowper's Wharf Installation consisted of one of Robey's 10 h.p. nominal semi-portable ordinary high pressure non-condensing engines, one No. 7 Brush dynamo, and 15 arc lamps. The cost per annum was as follows:—

Coal at 14s. 6d. per ton	£155	6	5
Water 1s. 6d. per 1,000 gallons	15	9	0
Cartage	0	13	10
Stores and repairs	75	1	2
Wages	369	0	0
	£615	10	5

The lamps were worked for 3,804 hours per year ∴ 3,804 × 15 = 57,060 horse-power hours $\frac{£615\ 10s\ 5d}{57,060}$ = 2·5d per lamp per hour or 5d. per B.T. unit. equivalent to gas at 2s. 10d. per 1,000. This was merely working expenses, allowing 10 per cent. on £2,000 the cost would be equal to 6·7 per B.T. unit = gas at 3s. 10d. per 1,000.

So that it would be seen in each of these two installations they were producing the light at a much lower rate than the Gas Company. For the coming year he trusted it would be less, as there was a reduction of 1s. 1d. per ton in coal and 10s. per 1,000 in carbons.

Post Office.—Post Office Installation consisted of one 12 horse power Otto gas engine, 1 Edison and 1 Weston arc dynamo, 70 incandescent, 60 watt lamps, and 4 Weston arc lamps; making a total of 7,200 watts per hour. The lights were used on an average 5 hours per day = 1,560 per year. The cost of working was as follows:—

Gas at 5s. 3d. per 1,000 ...	£175	11	9
Wages	156	0	0
Stores and repairs	71	1	3
Cartage...	1	4	4
	£403	17	4 say £404

∴ £404 ÷ 11,252 unit hours (1,560 hours + 7⅛ B.T. units) = 8·6d. per B.T. unit, which was equivalent to gas at 4s. 11d. per 1,000. To include 10 per cent. interest on this would equal gas at about 6s. 6d. per 1,000.

From these figures it would be clearly seen that an overhead system of high tension could more than compete with the Gas Companies and still pay respectable dividends, but as he stated before, this would not be allowed in a crowded city, hence the necessity of some scheme which would get over all these difficulties. If Mr. Van de Velde's figures were correct and would hold good

in New South Wales, he should not experience any trouble in bringing his scheme to the fore. As regarded hydraulic power, he (the speaker) must plead ignorance, and, therefore, could not refute any of the statements contained in the paper, but would leave it for abler men to do.

Mr. Shellshear stated that the quantity of water which would be required in Sydney for such a system as that proposed would be enormous. Mr. Van de Velde said that 100 lamps would require 10,000 cubic meters per annum, or 2,200,000 gallons. For Sydney we should require about a million lamps, which would take something like 22 billion gallons of water per year. Also, that he was afraid that even in Sydney the question of hydro-dynamos was a serious one, owing to the cost of water supply, and up country, where sometimes you could not get water at any price, the matter was out of all consideration.

Mr. H. E. Dickinson remarked that it was a matter for regret that Mr. Van de Velde in preparing his paper did not devote as much pains to the calculations as he did to the declamatory portion. Several of the more salient points were touched upon in the discussion which followed, notably by Messrs. Fischer, Selfe, Fitzmaurice, and Shellshear, showing that accuracy had been in a great measure sacrificed to enthusiasm in the author's advocacy of his countryman, Mr. Van Rysselberghe's scheme; and although with more careful treatment it might, perhaps, be shown that under certain exceptionally favourable circumstances this system might be feasible he (the speaker) was afraid that we, as a scientific body, could only come to one conclusion, viz., that it was unsuitable for adoption in Sydney.

In the earlier portion of his paper Mr. Van de Velde endeavoured to reproduce the excited times following the Paris Exposition of 1881. An electrical "boom" was inaugurated, and the promoters of "bogus" companies were in great form, as anything which by an ingenious and craftily-drawn prospectus could be represented as tending to break up the monopolies of gas companies was eagerly taken up by the public, and many investors were thereby ruined.

But we had now settled down to a more reasonable frame of mind in this respect. The wonderful developments that the last decade had witnessed in the economical conversion of energy into electricity had familiarised its use in more operations than simply lighting. We had seen the antagonism between gas and electricity gradually converted into a firm alliance, and gas, in a word, had become the handmaid of electricity. Instead of being overturned, it seemed to him that gas companies could, if so minded, become the cheapest purveyors of electricity. It was no news that lighting by gas was a wasteful, unscientific and unhealthy process, but it was not so widely known that gas when used as a motive power gave better results as a lighting agency through the medium of electricity than by its imperfect combustion in the ordinary way.

* Sir David Salamon's comparison was given in the following comprehensive manner:—

"A gas-engine requires about 20 cubic feet of gas per indicated horse-power per hour, which in a properly designed installation should give current for at least 8 incandescent or glow lamps of 16 c.p. each. Consequently for every 20 cubic feet burnt in the engine there is produced a light equivalent to 130 candles or more, since a 16 c.p. lamp gives rather more than its nominal (lighting) power. A gas burner made to pass 6 feet of gas at normal pressure gives about the same light as a 16 c.p. lamp. Hence 20 cubic feet of gas burnt in the usual manner will produce a light of about 55 candles." The result is, therefore, about $2\frac{1}{3}$ times in favour of electricity.

No doubt, some of the members present had seen results as good as those quoted, obtained by the use of gas and air, in the proportions necessary for more perfect combustion and light obtained by the incandescence of a platinum burner. The economy of the gas engine had considerably increased of late years, and it had shown itself to be a very convenient motor, and when the manufacture became more general, on the expiry of patent rights, and competition reduced the cost, a great future was before it.

* "Electric Light Installation," Whittaker & Co., London, 5th Edition, 1890.

That the distribution of electricity by conductors was open to grave objections, no one would deny; but some of Mr. Van de Velde's statements in condemnation of the system had been shown to be grossly exaggerated, more especially as regarded the section of cables required.

One misstatement he would notice, which, however, was comparatively a minor matter, viz.: that "Electricity was only one particular form of energy." This was a very general assumption, but the latest developments of electrical research had shown that such was not the case, but that electricity was material, and that Dr. Franklin's view was in the main a correct one.

Professor Oliver Lodge, in the preface to his "Modern Views of Electricity" stated: "Heat was once thought to be a form of matter; it is now known to be a form of energy. The question remains, 'What is energy?' Electricity has been thought to be a form of energy; it has been shown to be a form of ether. There remains the question, 'What is ether?'" He showed that certain electrical phenomena were inconsistent with any other than the material theory.

A systematic analysis of Mr. Van de Velde's assertions would probably take much more time than the paper itself; for it was much easier to asert than to refute.

To put the matter in as brief a compass as possible: we were told that Mr. Van Rysselberghe had brought out a combination, called a "hydro-dynamo," which, in conjunction with a hydraulic power distribution, was to work wonders: giving the consumer light at a lower rate than gas, and a much superior article, and returning a profit to the fortunate shareholders of original stock of 100 per cent.

Unfortunately for this glowing picture, the figures advanced in support turn out delusive, and an analysis of them dispels the mirage.

M. Van Rysselberghe estimated the cost of 1 cubic meter of water under pressure, at Brussels, at 17½ centimes or 1¾d. to the Company. These were figures which could be checked against wel authenticated English practice. Professor Robinson, in his work on hydraulic power, gave the average cost for engine power + 15

per cent allowance, as interest on capital and depreciation of eight hydraulic pumping stations in Great Britain, at 1.26d. per unit of 100 foot-tons delivered in the main. This was, of course, past the accumulator, but had nothing to do with the cost of distribution.

1 cubic meter × 50 atmospheres × 80 per cent. = 1.33 units of 100 foot-tons, and at English rate became 1.67d, or quite close enough to the 1.75 for argument.

But the cost of power at the accumulator was a very different thing to that of power delivered at the consumers' motor, crane, or lift. The distributing mains had to be laid, and the charge to the consumer must include the interest on the outlay, consequent on the reticulation, the commercial expenses, and the profit to the company.

The London Hydraulic Power Company's charge ranged from 8s. per 1,000 gallons to small consumers, with a minimum charge of £5 per quarter, to 4s. per 1,000 to large consumers. The Melbourne Company's charge was about the same, he believed; therefore, he did not see how, in Sydney, the price could be any less.

One thousand gallons = 4.54 cubic metres, so that on a similar scale, the charge would range from 1s. 9d. or 10½d. per cubic metre. The great number of consumers would probably be on the smaller scale, as it would pay a large consumer of power in a compact area to generate his own by either a steam or gas engine. The mean rate of returns to the Company, as per schedule rates would, therefore, be about 6s. per 1,000, or per cubic metre $\frac{6}{4.54}$ = about 1s. 4d. per cubic metre.

The cost of the water must be added, or 1s. 6d. a 1,000 = 4d. per cubic metre, making 1s. 8d. as the cost to the average consumer,

This cost of distribution might, at first sight, appear to be very heavy; a little consideration would show that it must necessarily be so. The cost of materials in mains, branches, and valves, labour in laying them through streets and connecting to the premises of the consumers; repairs, renewals, and depreciation, office expenses, and the Company's profit. It was,

therefore, not surprising that the actual cost of pumping should be merely a fractional part of the cost of the power delivered to the consumer.

When, therefore, Mr. Van Rysselberghe was represented as asserting that because the cost of pumping was $1\frac{3}{4}$d. that a charge of $3\frac{1}{2}$d. would return a profit of 100 per cent., he was either making a grave error, or was misrepresented by Mr. Van de Velde.

This error was, however, persisted in throughout the paper, and, of course, calculations on that basis must be equally misleading, and required to be multiplied by 6 to obtain an estimate of cost sanctioned by actual practice.

Again, the quantity of water under pressure to generate electricity in the typical installations was very much under-estimated. Taking the 40-lamp installation first, it was stated that 2,000 cubic metres per annum, or 13.7 cubic metres per hour was sufficient to generate the current.

$$\frac{2204 \times 1.37 \times 50 \times 14.7 \times 2.305}{33{,}000 \times 60} = 2.58 \text{ ind. horse-power,}$$

or, the highest possible amount given out by the pumps, but as the maximum efficiency in the main was at the very outside 80 per cent., a cubic metre would only carry 206 indicated horse-power to the consumer's motor. Under these considerations, it was important to the consumer that he should employ a motor which would return as much of the work stored in the water which passed through his meter as possible, and we had to consider the motor of M. Van Rysselberghe. Whatever it might be, it was only represented as giving out an efficiency of 50 per cent. This meant that every $2\frac{1}{2}$ indicated horse-power at the pumps gave back 1 indicated horse-power at the dynamos. Sir D. Salamons stated the results of practice as 10 lamps per indicated horse-power, which was a well-known allowance. The conclusion, therefore, that was forced upon us by this analysis, was that the quantity of water under pressure which Mr. Van de Velde wished us to consider as sufficient for a 40 lamp installation, was in reality, only qualified for one of 10 lamps. This conclusion was corroborated by the

figures Mr. Van de Velde put on the blackboard for us, which were stated thus: 1 $M^3 = 1$ electric horse-power $= 746$ watts, but as his subsequent factors were incorrect, namely, the number of lamps per electric horse-power, which should be 10 instead of 14, as he stated, and the cost of water which had been shown to be very much under-estimated, it was unnecessary to follow his equation any further. Another example he (the speaker) must refer to, as illustrative of the general want of accuracy in the author's figures was the relative quantities of water under pressure required for the two typical installations. The smaller one which he had dealt with, was stated to require 2,000 cubic metres for 40 lamps, the larger one for 120 lamps, or three times the number was said to require, 10,000 cubic metres, or five times the quantity. A brief consideration of these figures showed that even were the estimates reliable, the motor portion of the hydro-dynamo for which so much was claimed, was a most wasteful machine, eminently unsuitable for such a limited water supply as ours. To sum up the analysis, the water under pressure would cost the consumer from five to six times as much as Mr. Van de Velde estimated, and the quantity required with Mr. Van Rysselberghe's motor would probably be from $3\frac{1}{2}$ to 4 times as much as estimated in the paper.

Mr. Callender said: In considering the paper read by Mr. Van de Velde, there were two points upon which, it appeared to him, the whole question really turned.

First, the statement that the transmission of electricity at high tension was inadmissable on account of the danger to life. While admitting that at a tension of 2,500 volts, which was about the highest in use at present, electricity in inexperienced hands was dangerous, we had ample proof that in the hands of a competent electrical engineer it was perfectly safe. The many eminent authorities quoted by Mr. Fischer as to this would seem to be quite sufficient to convince any one; but we had, if possible, a more convincing proof, in the large number of central stations all over the world now using this system. Among others, he might instance the Grosvenor Gallery, and the Brompton stations in London, Eastbourne, Hastings, Rome,

Turin, Milan, and Tours, and many other cities on the Continent, in most of which the mains were underground, and where there had been no fatalities up to the present in spite of the high tension in use (2,500 volts).

It was true that in America there had been a number of deaths, where the high-tension system was in use to an enormous extent; but every one of them was directly traceable to careless work in fitting up the plant; or, still more frequently, to the low class of insulation used on the wires and cables.

The second point was the question of cost, and this was really the key of the whole matter. Mr. Van de Velde stated that to transmit electricity to light 1,000 lamps at a distance of 1,000 meters at a loss of 5 per cent., would require 720,000 kilos of pure copper, costing, at 2s. per kilo, £72,000, or with insulation, £144,000.

Now, accepting these figures as correct, we could by the use of the three-wire system of Mr. Edison and Dr. Hopkinson, reduce this at once to 216,000 kilos, still keeping the E.M.F. at 100 volts, and the loss at 5 per cent. This amount of copper would cost, at 2s., £21,600, or, with insulation, £43,200.

But if we increased the E.M.F. to 500 volts, a pressure which was admittedly safe, and use the three-wire system, we could still further reduce the weight of copper to 9,500 kilos, costing, at 2s., £950, or, with insulation, £1,900.

Again, by the use of the alternating system at a pressure of 2,500 volts, which had, he maintained, been proved to be perfectly safe. We could still further reduce the cost.

With an E.M.F. of 2,500, to give a loss of 5 per cent., we should require only a weight of copper of 1,500 kilos. As this conductor would be somewhat smaller than experience had shown to be satisfactory, he would assume a loss of only 1 per cent., instead of 5 per cent. This would require a weight of copper of 6,500 kilos, costing, at 2s., £650, with insulation, £1,300.

In conclusion, he hoped he had shown how the cost of the mains could be reduced from the alarming figure of £144,000, given by Mr. Van de Velde, to the comparatively insignificant

figure of £1,300, and this with a loss of only 1 per cent., instead of 5 per cent., and considered that we were justified in giving a direct negative to the statement of Mr. Van de Velde's that "Electricity cannot be transported economically."

Mr. Webb stated that Mr. Van de Velde had asked if any Companies could be named who were supplying the electric light at the same price as gas, and paying a reasonable dividend. There was the Central Station at Milan, which had been paying a dividend for some years. The last one paid was 4 per cent., and they put by a large reserve fund. There are two Companies in Berlin, one paying 5 per cent., and the other $7\frac{1}{2}$ per cent.

Mr. Van de Velde also stated very emphatically that electricity could not be transported economically. Behring, in his book, gave the commercial efficiencies of electricity, hydraulics, pneumatics, and wire rope. At 100 metres the commercial efficiency of electricity was 69 per cent., and of hydraulics 50 per cent. At 1,000 metres, electricity 66 per cent. efficiency, and hydraulics 50 per cent., and on further increasing the distance to 20,000 metres, the commercial efficiency of electricity was 32 per cent., and of hydraulics 20 per cent. Then the author gives efficiencies and losses in the conductors. But he must remember that with electricity, when transmitted to 1,000 metres, it was in a position to give light at once, but with water power, the water must first of all pass through the hydraulic motor, where there was a loss according to his own showing of 50 per cent. Then there was another loss of 10 per cent. in the dynamo, at the very least, which gave 40 per cent. efficiency, whereas allowing him 17 per cent. loss in electricity, we had 83 per cent. efficiency by means of electric power.

Again quoting from Behring's book, the capital outlay required for the various methods of distribution, up to 500 metres, hydraulics had rather the advantage. The ratio of capital outlay per horse power for 500 metres, for 5 horse-power: electricity, 78; hydraulics, 66; but at 1,000 metres, the capital outlay for electricity was 81, and of hydraulics 87, and when increased to 20,000 metres, the capital outlay of electricity was found to be

210, and for hydraulics, 1,180. Further, the cost of the water-mains increased considerably with the increase of pressure, but with electricity this was not the case, as there was but little difference between an insulation for a low and a high tension current. Mr. Van de Velde stated that his hydro-dynamos were to be as simple as a gas meter; but even then there must be a certain amount of wear, and it would also require a certain amount of attention, as it must necessarily run at a high speed, and no comparison could be drawn between it and a gas meter.

The main point of Mr. Van de Velde's paper was that he had taken a case in which he proposed to transmit to 1,000 metres or more, a current at 100 volts pressure, but he, the speaker, thought this was entirely out of the question. In America they seemed to hold to their transformer plants, and the demand for this type of plant was rapidly increasing.

In the paper, Professor Forbes was quoted as condemning all cables, but it was plain it was simply one particular kind of cable he condemned.

Mr. Ashcroft said he considered, as a new member, it would be an act of presumption on his part to make any remarks till he had become better acquainted with our proceedings, especially as he had not read the paper previously. But there was one point in connection with the paper that he wished to mention and that was that it seemed to favour a most wasteful application of hydraulic power. We had many contrivances—hydraulic engines—that gave a much higher percentage of efficiency than the one proposed.

Mr. Cruickshank said he had listened with great pleasure to the reading of Mr. Van de Velde's paper and the criticisms which the various speakers had passed upon it. He did not pretend to be able to speak with any degree of authority upon electricity; but there were one or two things in connection with it which perhaps might bear on the subject, looking at it from a mechanical point of view. It appeared to him that Mr. Van de Velde's paper,

condensed, stated two things. First of all, he said, in substance, at all events, that it was dangerous to transmit electricity at a high tension, and it was very difficult to get a uniform light. The other speakers had dealt with the financial part of the question; he had paid particular attention to the remarks of one or two speakers in connection with the point he had mentioned. Our friend, Mr. Fitzmaurice, had had very considerable experience of electricity, and he thought from the remarks made by him and by Mr. Cracknell that they were decidedly of opinion that electricity of a high tension was very dangerous. Now, on the other hand, Mr. Fischer and Mr. Selfe, and various others quoted from some most eminent authorities to show that electricity of a high tension was perfectly safe. Here we had two very antagonistic opinions. So far as our colonial electricians were concerned, they seemed to him to be decidedly of opinion that to use electricity of high tension would be a mistake, whereas on the other hand, the greatest authorities in the old country held a diametrically opposite opinion, that there was no difficulty and no danger in using electricity of a very high tension indeed.

Now, looking at it as an outsider, it appeared to him that high tension electricity was similar to high pressure steam. He remembered, and many of the members who were present no doubt would remember also, that with the first introduction of high pressure steam some of our best authorities and some of our most practical men were conscientiously and sincerely opposed to it because it was dangerous, and because it had all sorts of evils in connection with it. Not very long ago, in his own experience, when high pressure came in at something like 180lbs. to the square inch, standing on the top of the boilers, the safety valves blowing off and feeling quite a strange sensation. But now he was quite accustomed to it, and he thought that the difficulty in transmitting electricity of high tension was just the same as the difficulty we had experienced with high pressure steam. Steam, of course, was a very good servant and a very bad master, and he thought that electricity was just about the same. Any accidents that might have happened in connection with the transmission of high tension

currents were entirely due to the imperfection of mechanical appliances or ignorance on the part of the persons in charge. Of course, Mr. Van de Velde laboured under a considerable disadvantage. He was simply coming forward with a statement which told us very decidedly and without any reservation that the present practice of transmitting electricity was all wrong, and that he had got a scheme which was all right. Now, a person in that position making such a statement had a great undertaking before him, and one certainly not to be envied. At the same time he (the speaker) had no doubt that the author was perfectly sincere in what he had stated, but it appeared to him it would have been perhaps very desirable that he should have waited until this scheme of Mr. Van Rysselberghe's had been completed, when he could have given us some more definite information. For instance, did he propose paying for the water, or did he intend to use salt water? He (Mr. Cruickshank) thought the subject had been brought forward rather prematurely, as the scheme appeared to be very incomplete. The main question raised in the paper appeared to be whether it was dangerous or otherwise to transmit electric currents of high tension, and whether by transmitting it in such form and to considerable distances it was possible to obtain uniform light.

He was convinced, as far as his limited experience would allow him to judge, that electricity of a high tension would in the very near future be the standard practice of our electricians.

Mr. A. W. Tournay Hinde remarked that the fact of so many abler persons than himself having very fully discussed the system set forth in the paper, he felt some diffidence in calling attention to a few points in Mr. Van Rysselberghe's system for the distribution of power for electric lighting, not as the paper was entitled a "Hydro-dynamo system of electric lighting," for so far as had been shown the method of lighting proposed was not original, the novelty, if any, must consist in the method of supplying or distributing the power necessary for producing the light.

As other members had already directed attention to the fact some time ago, that power could be commercially distributed from

a centre by means of water or compressed air, and among the uses it could be put to was that of driving dynamos for electric lighting, he thought there was no necessity for him to enlarge upon the subject.

Mr. Van de Velde in the commencement of his paper asked whether any of the members could cite a single instance of an installation of central electric lighting at present running that paid for itself, and at the same time was cheaper for the light produced than gas. To find one we had not to go very far away, viz., Tamworth, in this colony, where the municipality had been lighting their town and also a small portion of private premises for the last eighteen months. The cost formerly for gas was £9 5s. per lamp per annum, with the electric light it had cost only £4 12s. per lamp per annum, which included fuel, water, attendance, renewals, etc., and 10 per cent. for depreciation and interest. Some of the lamps were over a mile from the station, and the plant was worked at an E.M.F. of 100 volts; it was in duplicate, and had run continuously since first installed.

So far as he could see, it appeared to him to be simply a case of hydraulic power and motors versus cables and transformers. Mr. Van de Velde urged in favour of water power, that the cost of the hydraulic mains laid were much less than in the case of electricity, and he gave 1s. per metre as the cost of laying a pipe to transmit six-horse power; this was equal to about £67 per mile. There were at present electric light mains in some of our up-country towns which had cost only £60 per mile, transmitting as much as 18 to 20 horse power, viz., those at Young. Regarding the cost of the apparatus used for transforming the power into electricity of suitable potential for lighting, and supposing we took as an example the case of a private house, with an average of 10 lamps, where M. Van Rysselberghe required in the system he proposes, a water meter, water motor, and dynamo, with its necessary ampere and volt meters, costing, he presumed, by the time they were fixed, somewhere about £35, a low estimate, which was made up as follows:—

Dynamos, 750 watts	£20	0	0
Motor, say	5	0	0
Meter	2	0	0
Amp. and volt ditto	7	10	0
Twenty-five per cent. for fixing ...	4	2	6
	£38	12	6

Instead of this apparatus, with its necessary wear and tear, oil, brushes, interest on plant, etc., there were at present in successful use Electrical Transformers, doing all that Mr. Van Rysselberghe's apparatus would do, and costing for the same power £10, including 25 per cent. for fixing.

Again, Mr. Van de Velde said the losses in transmission by his system were less than by electricity ; and well they need be, for if the efficiency between generating station and point of supply was taken into account, the results yielded were remarkable.

Taking another example, and working from the private consumer back to the generating station, in the first place, we had the hydraulic motor and dynamo. Mr. Van de Velde gave the efficiency of the motor at 50 per cent. for a small power. Now, those who had had anything to do with the making of dynamos knew that with a machine so small as one horse-power (which was sufficient for 10 lights) that the highest commercial efficiency obtainable even with a high-priced machine, was not much above 75 per cent. Here, then, neglecting the loss in the meter, we had 50 per cent. and 25 per cent., or 75 per cent. altogether, to place down as the first loss; and then, for argument's sake, assuming that the loss in the pipes or transmission was *nil*, we had to deduct the loss in the main pump at the generating station, say, 20 per cent., or a total loss of 85 per cent.; that was, 15 per cent. of the total power only was available for lighting purposes; or, for the one horse-power at the house it would take 6.66 horse power at the generating station.

Viewing electricity in the same way, we must first consider the transformer, and, taking this at full load, as in the other case, we had an efficiency of about 86 per cent.; this was all the loss at the house, and allowing in this case a loss of 5 per cent. in the mains, which was high, we had an efficiency of 81 per cent., and deducting from this the loss between the dynamo and the engine, say, 9 per cent., or a total of 70 per cent., which was available for lighting; or, as before, for the one horse-power at the house, it would require 1.43 at the generating station.

It was almost needless to add that if storage batteries were used in connection with the hydraulic motor and dynamo, as proposed in one part of the paper, that the losses would be still further increased.

Of course he (the speaker) was well aware that efficiency in the methods employed did not necessarily always mean a commercially paying concern, but in this case it had been clearly shown that the medium proposed to be employed was costly, that the machinery and mains were more costly than those at present in use, and their efficiency was much lower, so that he did not see when Mr. Van de Velde stated that the present electrical systems could not be made to pay, how his system could, especially if the total interest and depreciation of all the scattered plants was taken into consideration. He trusted in Mr. Van de Velde's reply he would endeavour to explain some of the enigmas which at present surrounded Mr. Van Rysselberghe's system of distribution of power for electric lighting which he proposed the municipal councils of this colony should take up.

Mr. Webb said he would like to give a few figures showing transformer efficiencies obtained at a test at Frankfort-on-Main :—

Full load	95 to 96 per cent.
Half load	93 to 94 „ „
Quarter load	90 per cent.
One-eighth load	80 to 82

Mr. Fitzmaurice said he would like to explain Mr. Cruickshank's reference to himself with regard to the high tension

system. He (the speaker) limited his remarks to 1,500 volts tension. 1,000 to 1,500 volts could be carried with safety, but over that tension it was troublesome. Electricity was quite different to steam. It had a great many more obstacles to contend against.

The President stated that before calling on Mr. Van de Velde to reply, he thought it would be admitted that the references in the paper to himself should be answered.

In the fourth paragraph, page 31, the author said as follows: "You will see from the substance of the paper to which the author now asks your attention, that if our President had gone a little deeper into the matter he would probably have arrived at a slightly different conclusion." Again, in the seventh paragraph, page 34, he said: "This is the conclusion arrived at by one of the ablest electricians of the day, and yet in the face of it our President in his last address gives the example of an American Company which intends to carry the electric current to a distance of no less than twelve miles before distributing it." The information here questioned was published in the *Engineering and Mining Journal* on the 4th January, 1890, and was as follows: "The Westinghouse Electric Company has just closed an important contract with the Wellametta Light Company, of Portland, Ore. The company is to furnish 10,000 incandescent and 100 arc lamps, together with the wire necessary for operating the same. *The current is to be carried twelve miles before being distributed*, a thing never before attempted in this country. For that purpose a specially constructed machine, capable of producing 4,000 volts is to be used. The cost of the entire plant, including the distributing station building, will be in the neighbourhood of $200,000. The completion of this plant will be the inauguration of electric lighting in that city."

That proved conclusively the accuracy of the remarks contained in his Presidential address.

There were several other matters he would have liked to have dealt with; but as so many had spoken on the question and had invariably taken the same side, he thought it unnecessary to follow the same line.

Before concluding he wished to draw attention to certain contradictions which appeared in the paper, and would cite as examples the following paragraphs :—

"*Electricity cannot be transported economically.* Facts have demonstrated the veracity of this conclusion."

"Electricity at high tension is transported comparatively cheaply, but it becomes dangerous for those manipulating the machines and the wires. In more than one American city, the transport of electricity is done at 4,000 volts tension, but it would be difficult to number the victims it has made."

"In conclusion, the electric current, which in the general opinion is so easily transported, is not transportable at all."

And again :—

"It is quite possible to create in the heart of a big city, where one can depend upon a large consumption within a small radius, a central station for the production of electricity, and so compete advantageously with gas from a purely economical point of view."

"Are there any of you gentlemen who could name a company that sells the electric light at the same price as gas, the said company being in a prosperous condition, and paying a reasonable dividend ?"

Regarding the cost of cables, it had been conclusively proved by experience that electric currents of a very high tension could be carried upon an exceedingly small wire, and it was a perfectly erroneous statement of Mr. Van de Velde's that it was necessary to pay fabulous sums for them. There were many things in the paper that might be debated, but he thought they all tended in the one direction ; and so long as he had proved to you satisfactorily that the remarks he made in his opening address this year were what you would naturally expect them to be—authentic—he (the President) was perfectly satisfied.

Mr. Van de Velde, in reply to the various criticisms on his paper, stated with regard to his remark that the electric current was not transportable had evidently been misconstrued, as what he intended to have conveyed was that it could not be economically

transported. He was sorry he had omitted to mention in the paper that M. Van Rysselberghe proposed to use salt water, as this would of course materially reduce the cost of the system. Mr. N. Selfe had asked a number of questions, but he (the speaker) was sorry he could not supply the information at present, but he hoped on some future occasion to have the opportunity of again bringing this matter before the Association, when he would be in a position to supply all data asked for and also exhibit one of the motors.

The President, in conveying the vote of thanks to the author, remarked that though we had ranged ourselves opposite to Mr. Van de Velde yet we had derived a considerable amount of information in consequence of his reading this paper. The discussion of such a question was exceedingly beneficial to our members. It induced them to study the subject thoroughly so that they might be prepared to answer whatever arguments were used in the course of discussion. There was no doubt that Mr. Van de Velde laboured under a very great disadvantage here from the simple fact that he had not a motor or a model of a motor, nor yet had he plans or anything by which he could give us an accurate idea of the proposed machine. However, he (the speaker) was sure the thanks of the Association were due to Mr. Van de Velde for his paper. With regard to the utilisation of salt water in connection with Mr. Van Rysselberghe's scheme, the question was what action it would have upon a pipe at a pressure of 750 lbs. to the square inch. If he might use his judgment on a matter of that kind, he would say that instead of having pipes underground, as the municipal authorities had to-day, for seven years, he questioned whether they would last three years. Experience must prove conclusively to us what influence salt water would have under such circumstances before Mr. Van de Velde's scheme could be successfully put before the public. He was sure that those of you who had differed from the views promulgated by Mr. Van de Velde had based your objections upon what you believed to be your own practical experience coupled with what you have read, and you have done so in all sincerity. He was also perfectly satisfied that if in the future Mr. Van de Velde could prove to you that the motor he

was advocating was one it would be to the interest of the community to adopt, that there was not one among you who would not turn round and give him every assistance in bringing his scheme to a successful issue. On behalf of the Association he had much pleasure in thanking Mr. Van de Velde for his paper.

12th June, 1890.

ELECTRIC TRACTION.

By Gustave Fischer, C.E., M. Inst. Mech. E., (London),

Vice-President Engineering Association of New South Wales.

The practical demonstration of the applicability of the modern electric-motor to the propulsion of vehicles with flanged wheels, may be said to date from the year 1879, when Messrs. Siemens and Halske laid down a small model railway at the Berlin Exhibition. The length of the track was about 500 metres, and the train composed of a small electric locomotive and carriages for the passengers, which were simply small platforms mounted on low wheels, with two rows of seats facing outwards, parallel with the track. The locomotive was composed of one of Siemens' dynamo-electric machines, laid horizontally on a frame-work with wheels, the bobbin was placed parallel with the line, the rotary movement of which was transmitted to the driving wheels by means of spur and bevel gear. The electric current was transmitted to the locomotive by means of rubbers sliding along a bar of iron, fixed to the sleepers midway between the rails by wooden chairs to insulate it electrically from the soil, and extending the whole length of the track. The return current passed through the wheels to the rails and back to the generator. A lever served to connect or to interrupt the current, and thus to set the train in motion or to stop it. This experiment proved entirely successful, and led to the construction of an electric tramway of a permanent character between Lichterfelde and the Cadets' College, near Berlin, which was opened for traffic on the 12th May, 1881. The

length of this line is about 1½ miles; the vehicles are ordinary tram cars, carrying 26 persons, and each carries its own motor, the motion being transmitted to the wheels by belts working on grooved pulleys outside the wheels. The electricity is conveyed from the generator to the motor by one rail, the other giving the return. The rails had naturally to be insulated, and this led to a considerable amount of trouble; it was therefore decided not to repeat this method in future installations. This somewhat detailed description of the first electic tramways may be excused on the ground that it is thought desirable to place here on record the fact that Europe is the birthplace of the system of generating electricity at a fixed point by dynamos, and conveying the current through conductors, and sliding contact to the car whilst in motion, which forms the basis of most of the modern electric tramways now at work; although our American cousins have long since outrivalled and put in the shade the more conservative and slow-going Old World.

However, the ice was broken, and the application of the Electric Motor for rail-roading soon engaged the minds of the foremost men of the age. The installations at Portrush, Brighton, Moedling (near Vienna), Frankfort, Blackpool, Bessbrook and Newry, Brussels, and Hamburg, followed in rapid succession in Europe, and in America, Messrs. Field and Edison, at the Chicago Railway Exposition in the year 1883, showed the practical working of electric locomotion for the first time in public, and with most astonishing success so far as the electrical apparatus was concerned, although Mr. Edison had been experimenting at his laboratory, at Menlo Park, N.J., since 1880.

This was followed by the experiments of Mr. Leo Daft, with his electric locomotive Ampère, on the Saratoga and M'Gregor Railway. The performance of the Ampère, which weighed two tons, consisted in the hauling of an ordinary railway car, weighing ten tons, containing 68 persons and five persons upon the motor, the speed obtained was eight miles up a gradient of 1 in 57, with a curve of about 20deg., equivalent to a maximum duty of about 12 h.p.

About August, 1884, the Baltimore Union Passenger Railway Company opened for traffic the Hampden Branch, worked by electric motors on the Daft system. This road is just two miles long, with heavy grades and sharp curves, and was the first electric railway constructed in America for business purposes. At the outset a third rail-conductor was used, but overhead construction took its place at a later period. This road proved entirely successful, and is running to this day.

At the beginning of 1888 there were about 20 roads in operation in America, aggregating about 80 miles of track and about 90 motor cars; also about 20 roads constructing.

Since then progress in America has been phenomenal, while in Europe only a few roads have been put in operation in addition to those mentioned before. Early in the present year one or more electric railways were in operation or under construction in about 150 towns in the U.S. with about 1,670 miles of track, 2,650 motor cars aggregating 70,000 h.p., with a daily mileage of about 150,000 miles, carrying about 200 millions of passengers per annum and requiring 40,000 h.p. at the generating stations. It is estimated that 3,000 motors will be in operation during this year, with a traffic of 300 millions of passengers, and a return of more than three millions pounds sterling in fares.

In view of the foregoing the author will doubtless be excused for omitting almost entirely from further reference the European roads, as our local conditions have much more in common with those obtaining in the U.S. of America, and it will be to the practice in vogue in that progressive country that we shall have to look for a model for our requirements.

After these introductory remarks, the author proposes to consider in detail the various methods of applying electricity to the traction of vehicles in use at the present day.

Electricity is applied to traction in two very distinct ways, namely by means of storage batteries and secondly by conductors fixed along the tracks from which the motor-cars take the current as required.

Considered from a technical point of view, there is something very attractive in the proposal of having each vehicle to contain the power required for its propulsion, and it is to be hoped that eventually a successful storage-battery will be invented. Commercially however, at the present day, there are a number of serious objections to their use for traction-purposes. In the first place you have to carry about dead weight amounting to something like 3,500 pounds for an ordinary street-car, and this cannot be reduced until some other material can be substituted for the heavy lead plates. Then again in working steep and long grades, the chemical energy instead of exhibiting itself in the form of electrical energy, exhibits itself in the form of heat, with consequent injury to the battery; cars will ascend steep grades, but it is not deemed economical to attempt grades of more than about 5 per cent., and they must be short at that rate. There may be isolated cases in which storage cars might be used with advantage, such as comparatively long lines with easy grades and limited traffic; but the author is of opinion that the introduction of storage cars at the present stage for lines of any considerable extent, and where steep gradients exist, would almost of necessity lead to serious breakdowns.

Conductors, according to their location, may be classed as underground and overhead conductors. The first, which are fixed in conduits similar to those in use on cable tramways, are represented by Mr. Holroyd Smith's design for the Blackpool electric tramways, the Bentley-Knight system at Denver, Cleveland, Alleghany City and Boston, and at Buda-Pesth, where Messrs. Siemens have a conduit system in operation. However, the conduits in the American cities have all been abandoned, and the Blackpool and Buda-Pesth lines are, to the author's knowledge, the only ones now at work. The great first cost in constructing conduits makes the system equally expensive with the cable system, and while it is certainly undesirable in the latter to get the conduit almost charged with storm water and street detritus during heavy rains, this does not seriously interfere with the working, while, on the other hand, it may be the cause of

entirely stopping the running of electric cars for considerable periods on account of leakage and short circuits. It is also difficult of inspection and troublesome to keep the insulation in reasonably good order, on account of the continuous jarring to which the whole structure is subjected from the heavy traffic passing over it. The author does not wish it to be understood that he does not consider it practicable that a conduit could be constructed which would be fairly satisfactory, but the cost of such a one would be very great, and the mechanical details at switches, turnouts, &c., very complicated, requiring no end of attention. The fact that the Blackpool line has found no imitators in Great Britain is fairly conclusive evidence that the conduit system is not considered as being likely to return large dividends to possible investors, and as the average cost of working that line is stated to amount to about $4\frac{1}{2}$d. per car mile, and storage cars can and are now being worked at the same figure in London, there is no likelihood of any more conduits being built. Another drawback which the conduit system has, in common with cable roads, is the introduction of a large extra amount of ironwork on the street surface.

Overhead conductors may be divided into two classes, the one having a complete metallic circuit consisting of two parallel wires; the other only one overhead wire, the rails and earth forming the return circuit, and further, whether contact with the conductor is made on top, on the sides, or from below, and again as regards the manner of suspension, whether cross-suspension, side-suspension, or centre-pole-suspension is used. It would engage too much time to balance up the pros and cons of the various methods; suffice it to say that nearly all roads of importance now running, and, so far as the author knows, all roads building, use the single-wire under-contact system, with cross-suspension in comparatively narrow streets, and centre-pole suspension in wide streets; the principal points in favour of these arrangements being the neatness and simplicity of construction, ease and perfection of all switching, and the substantial and permanent attachment of the trolly arm to the car, rendering all danger from a falling trolly impossible.

It may be well, before giving a description of the details of the overhead system, to consider the principal objections raised against its introduction ; these are, the danger of the current, obstruction by wires and poles, and unsightliness. This latter objection is rather more æsthetical than practical, for these overhead lines and poles can be constructed so as to be hardly noticeable, the poles being of an ornate description, rather pleasing than otherwise. They also form an excellent opportunity for the attachment of electric lamps, either arc or incandescent, and this advantage in itself should compensate for all æsthetical objections raised. As regards obstruction, this cannot be regarded as serious, there being only one wire for each track, and a pair of poles, and crosswire every 120 feet about, or in wide streets a centre pole, which latter would be rather an advantage, as it would divide the road traffic, and give pedestrians a better chance in finding security in crossing over wide streets, as refuges could be arranged with very little additional expense. In a city like Sydney, where we have hundreds of telegraph and telephone wires in our streets, the few extra wires would certainly not cause much additional inconvenience, if such there is, as the author has never heard any complaints raised against these wires.

Considering the danger of the electric current to life, in case of a person accidentally coming in contact with a railway wire carrying a potential of about 500 volts, we find that Mr. Edison, the champion of low-tension currents, in his celebrated article in the *North American Review*, mentions that to insure safety he would recommend no current should be used with a higher potential than 700 volts ; as this is actually 200 volts more than that used for traction purposes, and in view of the fact that there is no instance on record of any one having been injured by a current from a railway wire, although a great number of employés have taken it under many varying combinations of circumstances and being persons of all ages and various physical conditions this objection may fittingly be buried finally. In case of an accidental cross between a railway and a telephone wire, which might lead to danger by fire, inexpensive and simple cut-outs are known, the use

of which will make it an impossibility for a dangerous current to enter any premises. Other safety appliances, such as "Young's Automatic Safety Cut-out," make provision in case of a railway wire breaking, to automatically and instantaneously cut off the current, thereby preventing all possibility of any person, outside the generating station, to come in contact with a charged wire.

We will now shortly consider the elements constituting the overhead electric road as used by the two American companies, who have between them constructed nearly all electric roads of any consequence which are at work at present, namely, the Thomson-Houston and the Sprague. We have:—1. The generating station. 2. The conductor from generator to car. 3. The motor on the car. 4. The gearing from motor to car-axle. 5. The return circuit to the generator.

Considering each element separately, we first have the generating station. This does not vary much in detail from electric lighting central stations, and as you all are no doubt acquainted with their construction a detailed description is superfluous. Special steps should, however, be taken to provide plenty of steam power behind the generator; and the engine should be of a type that will not vary much more than 2 per cent. in speed between running light and having to develop its full capacity almost at a moment's notice.

The conductor from generator to car, as now used on overhead lines may be properly described as the survival of the fittest. Siemens at first employed slotted tubes in which travelled a shuttle connected to the car by insulated wires. Next we find solid wires either singly or in pairs, superposed or side by side with a trolly running on top and connected to the car similarly to the one described above. This plan was, however, found to contain many drawbacks and the single wire under-contact method, in which the trolly wheel is fixed firmly to a mast projecting from the roof of the car, and is kept in contact with the conductor by means of springs from below, pressing it against the wire is now almost universally employed, the advantages being many, and some of which will be enumerated later on.

Turning our attention now to the construction of the overhead work, we find it to consist of a bare wire stretched over the centre of each track, somewhere about $\frac{3}{10}$ of an inch in thickness, of hard-drawn copper or silicium bronze. This is suspended at about every 120ft., at from 18ft. to 20ft. above rail level, either by means of a bracket, as in the centre or side pole construction, or from a thin wire cable stretched across the track from two poles fixed on the kerb-line, and is insulated therefrom by trolly line insulators composed of mica and india-rubber. The poles may be constructed of wood or, as is the case now in the best class of work, they are built up from wrought iron pipes of varying diameter, and admit of being ornamented to any desirable degree. They cause no more obstruction than an ordinary verandah post, and can be utilised—as mentioned before—for the attachment of electric arc or incandescent lamps without extra expense, and as they would, in that case, take the place of the existing gas pillars, the actual number of poles in the street would not be increased to any great extent. The poles are planted in concrete to a depth of between 6ft. or 8ft., attention being paid to make a good earth connection, so that in case of any leakage from the conductors passing down the poles, the electric current would be grounded, thereby preventing the possibility of a person leaning against the pole getting an electric shock. On short roads the conductor wires carry the whole current from the generator to the various motors along the track, but on long roads with heavy traffic, the fall in potential in such an arrangement would become serious at the more distant parts from the central station. Feeders are, therefore, employed, carried either parallel with the track, and connected with the conductor at short intervals, or the road is subdivided into sections, each section being fed by an independent feeder or feeders, carried overhead or underground, thereby not only keeping the potential fairly constant along the entire length of the road, but also avoiding the possibility of an entire break-down of the system, in case of fires, street blocks through processions, or even the rupture of a conductor wire; traffic could then still be kept up on either side of the break, and by

putting in cross-over roads in the track at the ends of these sections, the inconvenience would be only small and of short duration. Feeders, in the author's opinion should be put underground, as being less liable to interruptions, and for this purpose it appears to him that the construction of the conduit on the Callander-Webber system would be particularly suitable. Samples of this are before you, and, no doubt Mr. Callander, junr., will be good enough to furnish us with a few particulars thereof, during the discussion. The principal advantages of the single-wire under-contact method of constructing the overhead work are:— Neatness and simplicity of construction, ease and perfection of all switching, and the substantial and permanent attachments of the trolly stand to the car, rendering all dangers from a falling trolly impossible.

The next element to be considered is the application of the motor to the car, and we will here also at once include the consideration of the gearing transmitting the rotary motion of the motor to the car-axle. These portions of the electrical equipment will more than any other be instrumental in determining the mechanical as well as the financial success of an electric road, on account of being subject to great strains, and comparatively rough usage. We cannot do better than quote copiously from Mr. F. H. Whipple's book on "The Electric Railway," who deals very exhaustively with this subject. For comparisons only the two best known systems have been chosen, as almost all others are still more or less in the experimental stage, and have not given proof by lengthy records of satisfactory working.

Mr. Whipple says: "One of the most important subjects which can be considered is that of applying the motor to the car. Some inventors have maintained that the motor should be placed upon the front platform of the car-body itself, and that the rotation of its armature should be transmitted to the wheels by means of chain gearing. Others have maintained that the motor should be rigidly attached to the axles, and with direct gearing between the armature and the axles, and have one end supported from the car body. This would give great flexibility and ease to the entire car

upon starting. Others have maintained that the truck should be self-contained and that the car body should rest upon it by means of post gearing, as is the general custom in the horse car practice of the day. This latter system seems to possess the greatest number of advantages, and seems to have met with the most general approval.

"The Thomson-Houston Company started out with this general idea, and have elaborated their motor truck to almost a perfect degree. The truck of the day seems to consist of the wheels and axles connected by means of some rigid framework resting upon the journal boxes, which framework supports and carries that portion of the weight of a motor which is not carried by the axle. Direct gearing is employed in every instance. Chains, belts, rope, and wire rope of all descriptions have been tried, but all possess inherent difficulties which render their general adoption impracticable and impossible.

"In controlling the motors, inventors have brought forward a great many schemes. Some have been put forward upon the basis of simplicity and practicability. In the two most prominent systems of to-day a radical difference is observable.

"In one, the motors are so wound that all controlling influences are brought to bear upon the motor itself. In this system it can be readily seen that there is introduced a liability to accident in the very worst place possible. The motors themselves should be so built and constructed that they, above all other parts, would be free from any liability of breaking down.

"In the other system the motors are constructed with this primal object in view, and every precaution is taken to insure their longevity. The control of the current is made through what is known as a rheostat or resistance box. If this breaks down the motors still remain intact, and the car can be run to its destination. The rheostat, however, can be so constructed, that nothing short of the most extraordinary accident should cause it to give out.

"In street railroading, fine points in electrical science must be sacrificed. What is wanted is the motor that will go under all

circumstances, that can be depended upon, and that will stand the severest strain from year to year. A commercial efficiency on the repair sheet is much more desirable than a small electrical gain of efficiency in the motor itself. There is no possible condition that can be worse for electrical apparatus than under a street-car, and it has been only by the most patient and careful study that the most prominent systems of the day have been brought to the perfection which they have, and it has been done only by going frankly to the street railway men, ascertaining their views and studying into the difficulties which were to be overcome.

"The motor-trucks, as they are being built to-day, are proving themselves thoroughly capable of withstanding the severest of conditions, and it would seem to-day in considering the marvellous strides which have been made, that the highest point had been very nearly reached. It is certainly true that by far the majority of changes have been gone through, and that but slight improvement, if any, will be made in the future."

The Thomson-Houston system is the one using the rheostat, while the Sprague Co. use the commutated field for the purpose of controlling the motor. Sir John Fowler in his report sums up also in favour of the Thomson-Houston motor. The Sprague motor has no doubt a slightly higher electrical efficiency; but so would also a locomotive fitted with an automatic variable expansion gear have an advantage over the ordinary locomotive in use as regards consumption of steam, but for all that no locomotive-engineer would propose the use of such an appliance, as this saving of steam would not compensate for the extra complication and liability to get out of order; that type of locomotive or electric motor, which can do the greatest mileage without requiring to be taken to the hospital is the most valuable and economical in the end, notwithstanding the consumption of fuel may be slightly higher.

The last link to be considered is the means employed to conduct the return current, after having done its work, from the motor to the generator. In a great many installations this is done by conducting the current through the car axle to the wheel, and

thence by means of the rails back to the generating station. The rails are connected electrically at the joints by means of bent copper strips, as the fishplates are not often in a fit condition to conduct the current from rail to rail; sometimes earth-connections are also introduced at suitable intervals by plates buried into the damp subsoil, the earth in this case, acting as a conductor in the same manner as it is employed in telegraphy, and with the same advantage. The Thomson-Houston Co. in their more recent work, make use of a complete metallic return, consisting of a bare copper wire of same section as the overhead conductor, which is laid on top of the sleepers, midway between the rails and connected with the latter close to the joints. This is found to work most satisfactorily.

Having now described the component parts of the *typical* American electric street-railway of to-day, and which comprise three-fourths of all electric roads in existence and building in the United States, it may not be out of place to compare the various systems of traction in use at present for street-railway or tramway work. We have the horse, the steam, the cable and the various types of electric roads, of which we will, however, only consider the overhead system as described on the foregoing pages. It is generally admitted that cable-roads are vastly superior to horse and steam-roads and we shall therefore confine our comparisons to cable and electric roads. It will not be necessary to here recapitulate the advantages of the cable system, suffice it to say, that the electric system possesses all these and many in addition, except perhaps when it comes to working steeper gradients than one in eight. This latter, and almost as steep grades, have been worked successfully for about two years under the trying conditions of an American winter, with ice, snow, and sleet; a splendid performance of an electric car on a steep grade, being described in Sir John Fowler's report as follows: "On the Highland Electric Railway, at Lynn, Mass., there is a twelve per cent. grade, and a Thomson-Houston motor car, containing ninety-six passengers descending that grade was reversed and returned to the summit. Indicator cards taken at the time at the power station showed that

ninety horse-power was used in the maximum efforts." You will, no doubt, admit that this is a splendid performance, and as these motor cars are fitted with thirty horse-power motors, it goes to demonstrate that when a sudden call is made upon them, they can work up to nearly three times their nominal efficiency.

The advantages of the electric over the cable system are many, and may be classed as mechanical and financial; we will, however, consider only a few of the more important.

A complete stoppage of traffic, due to a break-down at the power station is almost impossible, the generating plant being made up of a number of individual steam-boilers, engines and electric generators; should any one of these give out at any time, a spare one can be started up at a moment's notice. With the cable system this is not the case, as the driving and compensating gears are all inseparably bound together; an injury to one of them stops the whole machinery, and, in consequence, the cars also.

Curves, switches, turn-outs, and cross-overs, which are admittedly all particularly objectionable in cable-roads, are no more trouble in the electric over-head work than similar constructions in ordinary surface track-work.

Single track roads on the electric overhead system can be worked as easily as in steam roads, while on cable-roads they are highly objectionable, as the cable has to be a complete loop.

The trouble of keeping the electric conductors in place and insulated is not one-tenth of that necessary to maintain the sheaves, curve wheels, &c. In the electric system there is nothing subject to any great strain or special wear, the main point being the preservation of the insulation, while in the cable system everything is constantly moving and wearing, necessitating frequent attention and repairs.

In the cable system the whole working depends on the cable, and if that breaks, traffic is at a standstill and cannot be resumed under much less than 10 or 12 hours. The breakage of an electric conductor is a very rare occurrence, it being constantly under the observation of the line men, and as a weak place would generally show itself by an undue deflection of the conductor,

could be attended to before an actual severance took place; however, should a break occur, this could be repaired in almost as many minutes as it takes hours to re-splice a cable, and as traffic could be still carried on on either side of the break up to where the feeders connect, only very little inconvenience—and that of short duration—would result therefrom.

The facilities for extending electric lines, running branch lines or increasing the power required to run additional cars are perfect. All you have to do is to put down the track and fix the overhead construction. If more power is required, add more generators at the station and provide additional feeders. In the cable system, on the contrary, the junctions are difficult to make, and if the gearing and power has not, at the beginning, been designed to provide for possible additions, a complete reconstruction may be required, and for branch lines a new power station will almost of necessity have to be provided.

The ease and certainty with which electric cars can be controlled is one of the most valuable features of the system under consideration. A cable car can only go at one speed—that of the cable; it cannot travel slower except at the expense of ruining the cable, and cannot make faster time, as it is not safe and practicable to run down inclines by momentum. The electric car can travel at any desirable speed, from a snail's pace to twenty miles an hour or more, can stop at top speed in a very short distance, and back out of danger if required. In crowded streets these advantages alone, even if in all other points the electric car were no better than the cable, would almost as a certainty procure for the electric the preference, more especially in an extensive system of tramways, where crossings of the tracks of different routes have to be provided for. It is here where the cable is at its worst; the crossing has to be negotiated by momentum, and should the car have to be stopped on account of danger ahead, we would (and the author has) witnessed the beautiful spectacle of the gripman and conductor pushing the cars the remaining distance to where the rope could be gripped again. How different with the electric car; it approaches the crossing at moderate speed, crosses

over at a walking pace, stops or backs if required, and so causes no more inconvenience than a horsed vehicle, while the cable car temporarily clears the road and stops all other legitimate traffic at these particular and generally congested parts of public streets.

There are many more mechanical points which might be urged in favour of electric over cable traction, but we will consider shortly a few of the financial advantages.

It is known that the cost of construction and equipment of a first-class overhead electric road is at least thirty-five to forty per cent. cheaper than a cable road. We know also that in the latter we can only get at the best about twenty-eight per cent. of the power generated at the station, as useful work at the wheel, while with the electric we obtain from fifty-five to sixty per cent. Again, the running expenses are from thirty to thirty-five per cent. less for the electric than for the cable. The location of the power-house for a cable road must, of necessity, be in close proximity to the track, whereas it does not matter much at what distance it is from the electric tracks. In the first case land of great value will most likely have to be purchased; the fuel will have to be carted, and water for condensing purposes, in all but exceptional cases, will not be readily available. The power-house for an electric road can be located either near a railroad or at the water's edge, resulting in a great saving as regards handling of fuel; land will be most likely obtainable at a cheaper figure, as you are not bound to any particular spot, and the chances are that condensing engines can be made use of, with consequent beneficial result to the exchequer.

In view of what has been said in the foregoing it is no matter for astonishment, that in the short space of time elapsed since the introduction of electric traction on a commercial basis, it has altogether outstripped cable traction, viewed from every standpoint. When we see that the West End Street Railroad Company of Boston, with about 217 miles of track, carrying daily about 300,000 passengers, after careful consideration of the various mechanical systems of traction, have decided to use electricity, in place of horse traction, and which change will involve the expenditure of some-

where near one million pounds sterling; again, when we consider that in Minneapolis a cable plant which had been bought to supersede horse cars at a cost of about £80,000 sterling, is thrown on the scrap-heap, even before being put in the road, to make room for an electric equipment; and further, when we read the following extract from the *New York Times*, viz.: "The forthcoming equipment of seven lines of street railway, and ninety-two miles of track in St. Louis with electric power, is an especially noteworthy indication of the superiority of the electric system on such roads, because of the extensive use of cable-motors in that city. Horse power was supplanted on several important lines not long ago by cable power, and probably cables would be put in now for the use of some of the seven lines just mentioned, if the owners of the property were not convinced that with electric power they could make more money and give better service. It is noticeable that they are not restrained by the large cost of making the change, which is estimated at 3,500,000 dollars." The natural inference is that the days of the cable road are past, and such will be henceforth only constructed in isolated cases. There is no doubt that cable traction was an enormous advance on all other known systems some years back, but it had to go down before the modern system of electric traction, for the reasons set out in the foregoing.

The experimental days of the electric tramway are past, their cost of construction and working are well known, and the commercial success of such an undertaking can be foretold with an equal amount of accuracy as in the case of a cable or steam road.

A glance into the future as to the probable limit to which it may be desirable to employ electric traction in place of steam locomotives may not be out of place. The author is of opinion that in the near future electric locomotives will be used extensively for suburban and branch line traffic, of which illustrations are already at hand in the United States. The Thomson-Houston Company have built for the West End Railway Company, of Boston, an electric locomotive, weighing seven tons, on four wheels,

of 36 inches diameter, fitted with two 20 h.p. motors, and capable of drawing four cars at a speed of 20 miles an hour, for heavy suburban traffic. It is also fitted with a small 1 h.p. motor working the air brakes. Another example is that at Sunbury, Pa., the connecting link between the Lehigh Valley and Reading railroads is an electric railroad, which is operated at a speed of 25 miles an hour, and which carries both freight and passengers between the two systems. The motor of the electric car in this case is single, and of 30 h.p.

The valuable experiments of Mr. Leo. Daft on the elevated roads in New York demonstrate that large trains can be hauled successfully, as, in October, 1888, his electric locomotive "Ben Franklin," hauled a train consisting of eight coaches, each weighing 12 tons, up a grade of 98·7 feet, at a speed of $7\frac{1}{2}$ miles per hour, making an average speed of 14 miles over the distance run. These experiments were carried on for several weeks, during which time valuable data and measurements were collected, from which it was calculated that by the substitution of electric for steam locomotives more than half the cost of fuel could be saved on the elevated roads.

However, even this may not be the limit, and the question, whether main lines can be worked successfully by electricity, suggests itself. The travelling public is constantly clamouring for higher speeds; to obtain these with steam locomotives either the diameter of the driving wheel has to be increased, or higher piston speeds would have to be used. To do the first we reduce the tractive capacity, and the piston speeds cannot be increased to a great extent without loss of economy.

It is at fairly high speeds that the electric motor, as now constructed, is at its best; motors of sufficient capacity to propel a heavy train can be constructed, and as there are no reciprocating parts, high speeds could be worked with more safety and less damage to permanent way than would obtain with steam locomotives. It is quite possible, that many of us here assembled will see the day when electrically propelled trains will cover the distance between Sydney and Newcastle in two hours, or even less.

The application of electric traction in mines has already assumed considerable proportions, and it is to be hoped that our mine-managers will soon avail themselves of this appliance, to take the place of the horses now employed, which would result in a purer atmosphere for the miners to work in and also reduce the cost of underground haulage, with a further possibility of being enabled to increase the output from the mines.

The author regrets much that the time at his disposal did not permit of his presenting a more elaborate and better-digested treatment of the subject ; what has been said is intended more as the basis for a discussion, which he hopes will be vigorously indulged in.

The following works on the subject have been consulted in the preparation of the paper, viz.:—" The Electric Railway," by Fred. H. Whipple; " The Electric Motor," by T. C. Martin and Joseph Wetzler; " Electricity as a Motive Power," by the Count Du Moncel ; also the various scientific periodicals dealing with the subject.

Description of Plates.

Plate I.—Represents an 80 h.p. Thomson-Houston generator, specially designed for power transmission.

Plate II.—Is an illustration of a Thomson-Houston 30 h.p. nominal motive truck.

Plate III.—Is a copy of an Ampère-Diagram clearly illustrating the enormous variations of power the motors are called upon to perform at very short time-intervals.

Plates IV. & V.—Are views of electric tramways on the overhead conductor system, from which the unobtrusiveness of poles and wires can be seen.

DISCUSSION.

Mr. Dickinson said : There are few questions of greater public interest connected with our profession than those which deal with the various uses to which electricity is being adapted, and we must congratulate ourselves very much on having the opportunity to discuss such a valuable contribution as that which our Vice-President, Mr. Fischer, laid before us at our last meeting. It possesses more than ordinary interest at the present moment, seeing that so many proposals have been brought under the public notice to remedy the deficiencies of our present tram service. That it is far from perfect most of us will admit, and there can be no doubt that any substitute which can be worked more quietly, more cheaply, and with equal efficiency, will meet with the general approval, and, probably in the course of time, replace the present system altogether. The success of the cable lines recently laid by the Melbourne Tramway Trust, and which most of us have seen in operation, has no doubt given them a prominence in public opinion, which makes it necessary for the advocate of any other system of tram propulsion to show substantial grounds of superiority ; for nothing, from a passenger's point of view, could well exceed the convenience and comfort of that mode of street travelling. They are also able to show good financial results ; but this is no proof that there is no better system, nor that better results would not have been obtained by another system. Mr. Fischer has shown us fairly conclusively that electric traction is superior to cable traction on roads which present nothing extraordinary in the way of gradient or curvature. But he confines his comparison to the cable system, which is only one of many other systems of mechanical traction, and many of these superior, in efficiency at any rate, to that system. Mr. Fischer, however,

does not disguise his preference for the application of electricity by means of a conductor from a generating station. If electricity is to be adopted, he (the speaker) entirely agreed with him that the conductor is better than the accumulator or storage system. Secondary batteries are far from having attained that perfection which would warrant their extensive employment. They are too heavy and not sufficiently reliable in construction to withstand the variety of shocks and jars to which they would be subjected in a tram car in constant use. The conductor system seems to have given excellent results, and the applications of it, whether underground or overhead appear to work equally well, so that there does not appear to be much to choose between them on the score of efficiency. So that taking it for granted that we have only the question of Electrical Traction before us, the question turns upon how we are going to carry our conductors. If overhead, we must multiply the already existing nuisance of posts and wires by which our streets are disfigured, or incur the expense of a subway or conduit by which they are led underground. There is no question of practicability; each has been shown to give thoroughly good results. The Blackpool Tramway Service has been in constant work for the last four years. Mr. Fischer, in his comments on the overhead system, states that the only objection to this conductor is the unsightliness of the necessary posts and wires. He (the speaker) could not entirely agree with him that this is an objection which we can afford to disregard altogether. No one who had noticed the rapidly increasing number of telegraph posts and wires (more especially since the general adoption of telephonic communication) can have failed to ask themselves—How long will a long-suffering public endure this encroachment? One of the principal complaints against the narrowness of our main city streets is that the architectural features of the many noble edifices that beautify them, and the number of which is yearly increasing, is discounted by the distance which limits the perspective effects, or rather renders them too pronounced. While granting this to be the case, from having several times nearly broken his neck in attempting to observe the progress in the upper regions of the

Australia Hotel in Castlereagh-street, is this effect improved or the lower portions of these splendid edifices rendered more visible by double rows of telegraph poles with fifteen to twenty sixfold rows of wires, which appears to be what we are coming to very speedily. Would it not be a more sensible proceeding to allay the nuisance than increase it? An outcry is sure to be raised sooner or later against this ramification of overhead wires. It has come in the United States, and the question has been very summarily settled. If a tramway is to be run in our main streets, let the conductor be underground, and put it in a subway, in which also provision can be made for telegraph and telephone wires as well, at any rate within the city limits. The matter of the overhead conductors is not such a simple one as Mr. Fischer seems to indicate. Take, for instance, a curve such as that at the statue at the head of King-street into College-street. The conductor must be kept approximately parallel to the curvature of the track all round the curve, which means that this fine open space would have to be covered with a network of posts and wire-guys to preserve the necessary curvature of the conductor. Where the roads are fairly straight, wide, and open for traffic, the overhead wires and posts, if properly lighted, would not be such a great disadvantage, and it is quite probable that the economy in first cost would warrant their adoption; but he could not help coming to the conclusion that they would be a mistake in the city, and if placed there would shortly have to be replaced by the underground system of conductor.

Mr. Fitzmaurice remarked that the subject before us this evening is one of especial interest to the engineering community. Electricity is playing a most important part in nearly every mechanical branch, so that it behoves the engineer to turn his attention to this wonderful science, failing to grasp the present opportunity, he will, in the near future, find himself in the background. Mr. Fischer has in a very clear manner described the progress, systems and capabilities of the various electrical tramways, and also compared the cost, etc., of working same with that of the cable system, showing a decided advantage in favour

of the former. He (the speaker) did not know that his remarks would bring anything new to bear on the subject, for Mr. Fischer has quoted statistics and given undeniable evidence from the greatest authorities on electrical traction, that he has taken the wind out of the sails of those advocating this system. In discussing this subject he hoped to hear the opinions of those gentlemen in favour of other modes of traction such as compressed air, cable, etc., for at the present time our Government and Municipal authorities are considering which system will be the most advantageous one to adopt. Any person viewing our system of tramways cannot help admitting that it is a mistake from beginning to end, although at the same time they are a boon to the travelling public. With steam traction the working expenses are necessarily very high, for each train of cars is supplied with a steam motor weighing about nine or ten tons, and requiring two skilled men to work it. The wear and tear of these engines, owing to dust and mud, is considerable, so much so that it is necessary to keep two (one very large one at Randwick) repairing shops and a large staff of mechanics constantly employed day and night. The permanent way is also damaged considerably, owing to the extra heavy weight of cars and motors. On the other hand, a person visiting Melbourne cannot but admire the complete system of tramways, which every one here knows is the cable system. This system has been a complete success to the promotors from the start; but, for all that, this system is not adaptable for Sydney. In Melbourne the streets are very wide, and mostly straight, while in Sydney they are just the reverse, being very narrow and crooked. Mr. Fischer states that only twenty-eight per cent. of the power given out by cable engine is available on the road. This you will admit is indeed very small. However, allowing thirty-eight per cent. available power in the Melbourne system, not more than twenty-five per cent. would be possible on the Sydney roads, owing to the number of curves and grades. Seeing, then, that both these systems are unsuitable, the question arises—which is the most suitable? Mr. Fischer has aptly pointed out that in the cable system should any part of the mechanism break down, the whole system (through

being inseparably bound together) is affected. The cable is the weakest, yet the principal, link in the whole system. The cars can only travel at one speed, and cannot be reversed. Should a delay occur through taking on or letting off passengers so that the cars following are right on top of one another, there is no chance of increasing the speed to make up for lost time, all must travel at the same rate; should the cable break the whole system is at a standstill for some hours. Not so with the electrical system. There are at least three recognised systems of electrical systems, viz., the storage or battery, conduit, and overhead (double and single wire), it will be advisable to take them in the order named for discussing the merits of each. The Storage System—The storage cells are placed in long boxes and fitted under the body of each car in cupboards; they are then connected to the motor which is under the car by means of the switches or starting levers through (in some cases) a rheostat or resistance. The loss in this system is forty-five per cent., made up as follows:—Ten per cent. from dynamo to accumulators in charging, twenty per cent. at least from accumulator to motor, ten per cent. motor to gearing, and five per cent. gearing to rails. And as each car has to carry an additional weight of 3,500lb., it is patent that a large amount of additional power is required when compared with the other systems. This is one of the greatest objections to the storage system, and one that would hold good in some of our existing lines where the grades are very steep. Mr. Fischer draws attention to the fact, that in working steep and long grades, the chemical energy, instead of exhibiting itself in the form of electrical energy, exhibits itself in the form of heat, thereby destroying the cells. He (the speaker) would remind him such is also the case with motors and dynamos, that where there is a resistance offered to the passage of the current the effect is to produce heat, and providing the resisting force (whatever it may be) is excessive, the result will be damage to accumulators, rheostat or motor, but this, as Mr. Fischer must be aware, is only a mechanical error, and is overcome by the insertion of automatic safety devices, so that only a certain amount of current can possibly pass from accumulators or dynamo to motor. Another

objection to the use of accumulators is the depreciation, for the life of a cell is only reckoned at two years for continual use, especially when used for traction purposes, as they are called upon to work at such variable loads that the tendency is to buckle the plates. (Makers of accumulators now guarantee to supply cells which will not buckle, at the same time allowing for rapid discharging.) Another defect in accumulators is the depositing of the peroxide of lead in the bottoms of cells, causing in a great many cases a practical short circuit, destroying their efficiency. This is caused by either the plates buckling or through the jolting of the cars. Another defect is the gas thrown out in charging or discharging, which must be allowed to escape. These two plates (produced) will explain what he referred to respecting the buckling and depositing of oxides. For traction purposes, the Crompton-Howell accumulators appear to him to possess advantages over either the E. P. S. or Elwell-Parker, inasmuch that in the former the plates are formed of spongy lead, by which means the oxides are more intimately connected with the lead, while in the latter make of plates they are made in the form of a grating in which the oxide is placed. Should any buckling or shaking take place so as to displace the oxides the whole square is lost. He did not consider the accumulator system (as it existed at present) suitable for the streets of Sydney. They certainly could be used for branch lines of easy grades similar to the Crown-street or Moore Park lines. To sum up the storage system he would quote Mr. Sprague, at the Kansas City Electric Light Convention:—"Professor Eaton, of Liberty College: I would like to ask Mr. Sprague what his principal reasons are for his conclusion that the storage battery system will not successfully compete with the overhead or direct wire system. Mr. Sprague: It is this—firstly, the simple reason is that you cannot three times convert energy at the same economy that you can once; secondly, because you carry a dead load of two tons around, unnecessarily, without energy. It weighs as much as thirty-five to forty passengers. There are no storage battery equipments in existence, whose storage capacity will permit of more than twenty-five or thirty horse-power being taken out of

them. If you limit their size and weight you reduce their capacity. There is no storage battery in existence in the United States which any company dare recommend, that you can put on a six per cent. grade and operate it, nor are there any battery cars in the United States, that he was aware of, that are working eighteen, nineteen, or twenty hours a day, as is the case with the direct system of supply cars." Mr. Sprague, in making these remarks (which he had curtailed) stated that he hoped as cordially as any man that the storage system would be a success, as he was financially interested in one. Direct Conduit System.—Without a doubt this would be the ideal system were it not for the many obstacles in the way. This system, however, possesses numerous advantages over the cable, inasmuch that the conduits are smaller, the conductors are stationary, and the power can be increased without any additional strain or wear of conductor, and where there are a number of curves the wear and tear of a cable is enormous; not so with the electric conductor, for it is only bent to the curve and is subjected to no more wear than if it were straight. In this system the rails form one conductor, the other is placed in conduit in duplicate (one on each side) and connected to the car by means of a sliding contact on the long shank. The objections to this system are (as Mr. Fischer points out) the complications of switching and damage by storm waters; this last objection is the only practical one which would prevent the adoption of the conduit system in Sydney, and it is owing to the same cause that the system has been a failure in America. So that until we have a perfect system of sewerage throughout the city and suburbs it would be folly to adopt this system of traction. Overhead Double-wire System.—This system has not been very largely availed of in America. By the use of the two wires the earth as a conductor is dispensed with, thereby preventing any disturbance (in the way of induction, etc.) to telephonic circuits, the current is carried from conductors by means of a two-wheeled trolly to motor. With the double-wire system the objections are numerous, inasmuch as there is a great liability to short-circuiting, for if the wires are placed too close together there is a liability of them being short-circuited

by means of the wind, and if placed too far apart would require a second trolly arm, which increases the weight on car roof. The most objectionable feature in this system is the danger of short circuiting at turnouts or crossings, especially where double lines exist, for the number of frogs is necessarily increased; at the same time it is almost impossible to thoroughly insulate the wires at the crossings, for in the case of a double line similar to the one at the junction of Elizabeth and Liverpool Streets the negative and positive conductors would cross at four different positions, and in a crossing eight positions, so that in passing over these crossings the current is broken, extinguishing the lights (of course it is only for a short duration); all of these obstacles entail a deal of extra labour and attention in keeping them workable. There is another point which must not be lost sight of, and it is this, that the resistance in conductors (providing these were of same area as used in a single wire system) of a double line would be twice that of a single line, for, by using the earth as a return, the resistance would only equal that offered in the single line, there being practically none in the earth. As this system has not found much favour elsewhere it is certainly not suitable for Sydney, so that we are obliged to accept the single wire overhead as the most economical, reliable, and safest system of electrical traction, and it is undoubtedly the simplest. The troubles connected with the double-wire system cannot possibly exist in the single wire, for the overhead conductors are of one polarity. Mr. Fischer had described the manner of operation so that it is useless for him (Mr. Fitzmaurice) to dilate on it. Mr. F. H. Whipple, in his work on "E. Railway," quotes the following total for constructing fifteen miles of track and 130 cars:—

Electric overhead, 791,000dol. (this should read 831,000, as he has omitted to calculate 40,000 for car-house and land).

do. conduit, 1,236,000dol.

do. storage, 1,253,200dol.

do. cable, 1,429,300dol.

By this it will be seen that the cost of a cable plant would be almost double that of the single-overhead, while the efficiency is as follows :—

System.	The loss in transmission being.				
	S.B.	Dynamo.	Conductor or Cable.	Motor.	Gearing
Electric overhead 65 per cent. =		10 per cent.	10 per cent.	10 per cent.	5 per cent.
Electric storage 55 per cent. =	20 per cent.	10 ,, ,,		10 ,, ,,	5 per cent.
Cable say 35 per cent.=			65 ,, ,,		

This system is simplicity in itself. Mr. Fischer mentions the use of the commutated field by the Sprague Co. He (the speaker) failed to see where any great liability would occur by the use of this method of regulation, for it seemed to him to be the most practical and economical method. By this commutated field the strength of the motor was regulated without the loss of power, whereas with the resistance or rheostat (the word implied loss of power) the power was reduced in motor at the expense of heating up the wire in rheostat; and as to comparing the two methods to a locomotive fitted with an automatic variable expansive gear, he could not see the comparison. With the commutated field the connections were a fixture, and operated by the drivers or car attendant, when required, by means of a switch. With an automatic variable expansion gear the governing power is always at work while the engine is working and the driver has no control over it. He did not wish, however, the members to think he was objecting to the use of the rheostat, for it is undoubtedly the simplest and most easily repaired of the two. Mr. George W. Mansfield, manager of the tramway department of the Thomson-Houston Co., makes the following ratio of costs in construction and working between the cable and electrical systems of traction :—

	Electricity.	Cable
Depreciation	1	2·04
Operating expenses	1	1·71
Construction of tramway ...	1	2·09
Motor, cars, etc.	1	1·21
Cars	1	0·81
Total	5	7·86
Average	1	1·57

That is to say, that to construct and work a cable tram for a given distance the cost would be half as much again as that of an electrical one of the same capacity. For this fact must not be lost sight of—in the cable system sixty-five per cent. of the total power given out by engine is lost in working cables, and whether the cars are working or not the cables must be worked. To do this, means a large yearly consumption of fuel. Not so with the electrical system, the loss being only thirty-five per cent. The load on engine is only in proportion to the power used by motor. Too much attention cannot be paid to the engines and boilers for generating station, as on these depend to a great extent the success of the line. The most approved type of modern engines and boilers should be erected in duplicate. In Sydney no difficulty would be experienced on that score, as we have abundance of coal and water for condensing, right at our doors; for, as Mr. Fischer points out, that with the electrical system the generating system can be erected anywhere to suit these conveniences. For a practical proof of the superiority of the electrical tramways over the cables, we have only to turn to America. The advancement of electric traction has been phenomenal. In one city alone (Boston) there were in 1889, 230 miles of track with 300 cars in operation. Mr. Ballou (Messrs. Thomson-Houston's representative), who is now in Sydney) and present this evening, superintending the erection of a short line of tramway in one of the suburbs of Sydney, informed him that there are now 1,100 cars running in the same city. Boston, from all accounts, is very similar to Sydney as far as narrow and crooked streets are concerned, so that no excuse can be made against the adoption of the overhead system. The *æsthetic* objection

(as Mr. Fischer terms it) should not hold much sway in Sydney when we are brought face to face every few yards in the city and suburbs with much more objectionable obstructions, viz., to the huge placards, etc., posted on every available wall and fence, yet we hear of no movement to abolish them. On October 19th, 1889, *The Electrical World* published a list of the electrical tram lines, showing there were 1,260·3 miles of track and 1884 cars operating on 179 roads, but during this last year a large increase has been shown in all branches of electrical traction. As a further proof of the superiority of the overhead system, he might mention that on the 179 roads just alluded to, only three are operated by storage batteries, one by double wire, and part of two by conduits; the remainder by the single wire system. There is one of our pleasure resorts at which this system could be carried out and worked by means of a turbine, viz., the Fitzroy Falls. At these falls there is an abundance of water, with a fall of between two and three hundred feet. The road from Moss Vale is very good, and with a few slight grades, the length is about twelve miles. The expense for working this road would be very slight, and the returns would no doubt be found to show a fair profit on the outlay, as it would induce thousands of people to visit one of the grandest sights in New South Wales. In conclusion, he trusted that this colony will follow the good example shown us by America by adopting the electrical system of tramways, this being the safest, most economical, and best system of traction.

Mr. Cruickshank said: Though he scarcely intended to speak, one remark made by Mr. Fitzmaurice gave him a little encouragement. He said unless engines and boilers were made of the very best quality, and up to the highest standard of mechanical efficiency, the electric tramway would be of no practical use. Perhaps a few practical remarks from one who has some little knowledge of the steam engine, though very little of electricity, may be of interest. He must congratulate Mr. Fischer upon his plain, practical and sensible paper. Respecting the merits of the two systems, it appeared to him that so far as the conductor system is concerned it has this advantage—that the

conversions of power are only two, that is the engine power has to be converted into electrical power, and this again into mechanical energy in driving the car; whereas in the accumulator system the conversions are three—first the engine power has to be converted into electrical power, then into chemical energy, and then reconverted into the mechanical energy which drives the car. Of course, all these conversions cannot be carried out without reducing, to some extent at all events, the efficiency of the system. Another thing to be considered was that in a crowded city like Sydney a conductor system is always charged and always unprotected, which he thought contained an element of danger; whereas in the battery system it was practically safe. From the references to Sir John Fowler and others contained in the paper, it appeared to him that the two systems required some development, which might result in the conductor system proving the best for the country and suburban lines, while the battery system would be found more satisfactory and safer in crowded cities. Of course he understood that the tension referred to in Mr. Fischer's paper was not to exceed 500 volts, which, according to Mr. Edison, was harmless, but there could be no question that the tendency was to increase the voltage very materially, because, like steam, the higher the tension the greater the efficiency, and certainly much greater the economy. Mr. Fitzmaurice remarked as to the importance of having the engines and boilers of first-class make and finish. Mr. Fischer says the uniformity of the motion should never exceed two per cent. He doubted whether this was done in ordinary practice, but he understood that several governors, Hartnell's and others, came near it. These requirements show that the design and workmanship of electric steam engines must be superior to ordinary standard practice, and mean more money for the steam power. The author of the paper states: "It is generally admitted that cable roads are vastly superior to horse and steam roads, and we shall therefore confine our comparisons to cable and electric roads." Under certain conditions he (the speaker) had no doubt Mr. Fischer was quite correct, and he joined issue with him in a sense, not from any special knowledge,

but because of the calm, cool way in which he disposed of the steam engine and the steam tramway as being out of the running altogether. Perhaps in this class of work he is quite right, but so far as he (the speaker) could judge it has never been practically demonstrated. The steam motor can do all that the author claims for the motor he advocates. It can practically go ahead or slacken in speed on the shortest notice; it is not dependent on a single wire or cable and a generating station which must have machinery in duplicate or triplicate. He knew that cables and electric motors could be run cheaper than steam trams are. The point he wished to take was a novel one. In the comparison of the efficiency of the cable with the electric car the former gives twenty-eight per cent. of the engine power, while the latter gives about double. It had often struck him that any motor that gave such small percentage of efficiency must contain some radical defect, looking at it from an engineer's point of view, and must have certain circumstances in connection with it to justify its adoption. But the fact remained that the efficiency of a steam motor is double that of a cable, and yet it does not pay to use it. He had no doubt if the Sydney trams had to be laid down again, and were so laid under the supervision of men who had the practical experience and the knowledge of what was required, they could be made to do the work much better than hitherto, and with a better financial return. It was not right to condemn a principle because that principle might have been carried out badly. For instance, we all know what gas engines had done. They have been very useful, especially for small powers. If we take one of Lenoir's early engines, we find it consumed ninety-five cubic feet of coal gas to get a horse power. If that had been a practical engine it ought to have consumed 3·77 to get a horse power. Since that time gas engines have been improved very much, and now, instead of something like ninety-five cubic feet of gas being required to get a horse power, we can get the same power with twenty-eight; dividing the one with the other we have raised the efficiency from four per cent. to thirteen, which is about the same as we get from our modern engine. Mr. Fischer says, in generating the current the

efficiency of his whole system, after the steam engine, is only ten per cent. of the value of the coal. So this efficiency, he claims, is only 55 per cent. of 10 per cent. — a result which is much inferior to our steam engine. With regard to copper wire one thing struck him, and that is in its power of conduction. The method of drawing wire seemed to him to contain an element which would reduce its conductivity to some considerable extent, because it would draw the molecules of the wire further apart. Whitworth, in making experiments with steel, found that its conductivity, when compressed, was much greater than that of steel made in the ordinary way. In a recent article by Ferranti, in charge of the Deptford installation, that gentleman had shown that a high tension of 10,000 volts was as safe as 500.

Mr. Elwell wished to say a word or two upon some remarks of Mr. Cruickshank's as to the efficiency of motors or dynamos, as he is under the impression it is much lower than it really is. There is no difficulty about making a motor or a dynamo return 95 per cent. of the power required to drive it, or the current put into it in the case of a motor; and there are dynamos and motors working at that rate of efficiency. There is another point in the case of storage battery traction which has not occurred to most people, and that is the great increase of the weight of the car caused by carrying the cells. That gives an extra loss of about 25 per cent., so that that rather tells against the battery system. Then about the locomotives. Mr. Cruickshank did not mention that when a car, or train of cars, is drawn by a locomotive you have to take along an extra weight of about 16 tons, which tells a good deal against the locomotive system. Then as regards the copper wire conductivity, it does not reduce it to any extent drawing it. Mr. Fischer's paper seems carefully written, but it is a little one-sided. For instance, he says our American cousins have long since put in the shade the more conservative countries of the Old World. He (the speaker) did not think there was anything in the States like the London and Southwark subway, which is now open, and which carries 150,000 people daily on only about three miles of line. There is a much larger

line under construction called the Central London line, where the trains intended to be driven will weigh 80 tons each. It must be borne in mind, that in England they have not had so much chance of putting down electric railways in consequence of the opposition of the municipal and local bodies. He might mention that a conduit is going to be made in Paris several miles long on the Lineff system. Mr. Fischer says it is to be hoped that eventually a successful storage battery will be invented. He (the speaker) had been making experiments for some time with an accumulator that had neither lead nor acid in it, and weight for weight was about half that of the lead battery. Mr. Fischer states that in case of an accidental cross between a railway and a telephone wire, which might lead to danger by fire, inexpensive and simple cut-outs are known, the use of which will make it an impossibility for a dangerous current to enter any premises. He (the speaker) did not think there was any safety cut-out which would prevent that, and the only way to prevent it was to use a completely insulated circuit. He says feeders should be put underground. Is it not better in that case to have everything underground? It makes it simpler, and everything is then out of sight.

Mr. Spruson, a visitor, said that Mr. Fischer's remarks concerning the Blackpool Tramway, wherein he would seem to consider Mr. Holroyd Smith's conduit as a typical one, and the fact of its practical financial failure a gauge of the possible success of conduits generally, can, however, hardly be accepted unreservedly. Whilst it must be admitted that, up to the present time, conduits have proved unequal to requirements, it cannot be said that it is beyond the range of possibility that a well-designed conduit would not prove a success in the Australian climate. Nevertheless, the great comparative cost of conduits and the few really practical advantages they offer relatively to the overhead system, would, under all ordinary circumstances, in his, the speaker's opinion, entirely preclude their successful competition with the latter system. There can hardly be a doubt that the storage battery cannot compete financially with direct contact systems. The reasons are manifold, and, it may safely be said, cannot be overcome

entirely, as proved by several arguments which have been put forward by Mr. Fischer; the chief reason is—as so clearly stated by Mr. F. J. Sprague at the late Kansas Convention, and quoted by Mr. Fitzmaurice—that energy cannot be converted three times at the same expense as that for which it can be converted once. Mr. Fischer has touched upon the question of danger. Now, the element of "danger," so-called, in an electric railway service is far less than it is in house-to-house lighting; but to the latter, for the year 1888, New York sacrificed only five lives, whilst gas and kerosene caused the loss of no less than 49 lives. As far as his knowledge went, there was not, up to date, the loss of a single life to charge against electricity used as a locomotive power. The objection to poles, upon the ground of obstruction, was one that existed mainly in the imagination of unpractical people. As to unsightliness, the American public may be said to have taken more kindly than otherwise to the use of overhead wires and mid-street and side-walk poles. He thought that he did not go too far when he said that he thought Mr. Fischer had not accorded the Sprague system its due meed of praise. Considering the question from a scientific point of view, that system should have been given as much prominence as any other; more so as it was daily coming to the front, and at the present time occupied a position just as exalted as its great rival, the Thomson-Houston system. As a proof of its success it might be mentioned that the Minneapolis 110 miles contract—spoken of by Mr. Fischer—had been obtained by it. The wholesale, unjustifiable condemnation of the Sprague governing system, enunciated by Mr. Whipple, and quoted in the paper under discussion, he could not pass without comment. The verdict was unfair, as it is unsupported by theory and by practical experience. The employment of feeders and sub-feeders to which Mr. Fischer refers, is claimed to be peculiar to the Sprague system. He could not understand that an electric motor could be prejudicially affected by reason of the controlling influence being brought to bear upon the motor itself, than he could understand that a steam engine could be injured by the employment of link motion. The practical experience of the present day, which was derived from

three and a half years actual electric railroad practice, with all sizes of motors and under all sorts of conditions, established the fact beyond the power of words to contradict, that Mr. Whipple's opinions on the question are merely speculative. The analogy drawn by Mr. Fischer between the commutated field and the loco-variable expansion gear does not hold. Applying to a steam engine for purposes of illustration, the equivalent of the Thomson-Houston rheostat system of controlling the motor would be to provide means whereby under all conditions of load the same amount of steam (pressure constant) is drawn from the boiler, but only sufficient used in the cylinder to do the actual work required. Such means would consist of a number of long coils of steam pipe, corresponding to the rheostat coils, through one or other of which the steam would pass from the boiler to the cylinder, and therein it would become reduced. The exact mechanical equivalent of the Sprague electrical method of governing by commutating the field was hard to conceive, because so free and perfect an action was not attainable in any mechanical combination. Roughly speaking, it was equivalent to substituting cylinders of varying diameter one for another (according to the work to be done) by the mere movement of a switch. But this analogy was very imperfect indeed. With fixed loads and grades the Thomson-Houston, or any other rheostat governed motor uses the same current with low speeds as with higher ones; the Sprague, or any other motor governed by commutating the fields under like circumstances uses current closely proportional to the speed developed. In a large installation this question of loss is very serious. The Sprague system offers special advantages in railway work where it is required to develop abnormal power in starting; the spires of wire in the field can be so joined up as to give about three times the effective turns of the spires in a rheostat governed machine when necessary, and thus, with a given current, develops a considerably greater torsional effort. The power of a motor depends upon the strengths of the fields, and these can be varied by altering either the current or the number of turns of wire. In the Thomson-Houston motor the current is

varied, but the number of turns of wire is kept constant; in the Sprague motor the number of turns of wire is varied, but the current is not interfered with. In the former, energy is lost in "throttling" the current; in the latter no such loss occurs. It might be mentioned that the commutation of dynamo fields is by no means a novel idea; if in connection with generators, practice has proved the safe applicability of the principle, there is no reason why it should fail when applied to motor construction; as a matter of fact, years of experience have shown that it does not fail when so used. In conclusion, he would like to refer briefly to a few remarks made by Mr. Cruickshank regarding the efficiency of an electric railroad system. That gentleman was evidently of opinion that in point of mechanical efficiency electric traction would not be a material improvement upon the present steam motor system. If it be allowed, as he thought it must, that the present motors consume ten pounds of coal per h.p., and that the efficiency of an electric system be as low as 60 per cent., and that a large stationary compound or triple expansion engine would consume say two pounds of coal per h.p., then the actual relative consumption would be—Electric system, about three and a half; steam motor system, ten per unit of work. Therefore, with the present fuel consumption, the amount of work done would be nearly tripled by the substitution, whilst the inconvenience and the expenses of wear and tear and operating would be reduced to a minimum.

Mr. Nixon: Mr. Fischer remarked that electricity is now being applied to mine traction. In the company that he had been connected with for some years there has been a discussion on the question of endless rope-traction. He sent Mr. Fischer's paper to the mine manager and he replies in this way: Can these cars do our work? Can they be erected at a cost as low as that we have been paying?

Mr. Kingsbury said there was one question he should like to ask Mr. Spruson. When he spoke just now of the tremendous amount of loss of energy in this resistance in the management of the cars does he know how much loss there is in that resistance?

Mr. Spruson: The loss that occurs is a regular quantity. Whether you are running the motor at full or slow speed you are using the same current.

Mr. Kingsbury: You do nothing of the kind. Respecting the overhead wire, we must expect to have some poles, and those are not the most ornamental things; but inasmuch as in America these subways have been tried and abandoned time after time, and overhead wires substituted, he thought we should profit by their experience. In regard to the cost, you can put up an overhead railway at half the cost of a subway. Then again, the cost of running an overhead tramway line is just one-third the cost of the cable line. In speaking about engines, Mr. Fitzmaurice was perfectly correct in saying it is absolutely necessary to have a perfect governor.

Mr. Howe said: Had he known that the subject of tramways was to be alluded to he could doubtless have collected a few notes together on the subject. As to the cost of working, and the outlay in construction, it was quite true, as suggested by Mr. Cruickshank, that the tramways in this city were very crudely laid down; the whole system was started badly and continued badly; and, doubtless, if the work had to be done over again under the supervision of experienced men, very different results would be seen. The cars were lumbering and unsightly, and excited prejudice against the trams from the very first. He had not the slightest doubt in his own mind that steam tramways could be worked in this city at one-third less cost than those worked at the present time. None of the engines that were used were adapted for the work—neither the Merewether, the Wilkinson, or the present American engines. These latter were constructed for the overhead tramways in New York; the Wilkinson was an utter failure, and so was the Merewether. Defective roads, too, had added considerably to the cost of maintenance. In Melbourne the cars weighed from $2\frac{1}{2}$ to 3 tons, the dummy of the car not more than 2, running over a 94lb. rail, while we were expected to carry a $12\frac{1}{2}$ ton motor and a five-ton car, carrying sixty people over a rail of 41lb., and badly laid at that, and with no attempt at

drainage. The rail itself was made the drain carrying the water and mud through the streets, and which by the centrifugal force of the wheel was carried up into the engine. Had the system been properly laid down, the cars and motors run into a proper central depôt where the cars could be properly washed, and the engines properly attended to, there would have been a considerable saving. Instead of that they drop their cars, some at one place, and some at another. One man at from 10s. to 11s. per day should be able to do what it takes a driver at 13s. and a fireman at 11s. to do.

Mr. Henson remarked that the question as to whether wires should be overhead or underground was one that would be very much debated before it was settled. He was inclined to the overhead. Mr. Fitzmaurice referred to the underground system. He did not think the sewers being constructed would get over the difficulty.

Mr. Fischer, in replying to the discussion on his paper, said he would do so as briefly as possible, considering that another very interesting paper was set down for reading this evening. The result of the discussion was highly gratifying to him, as there had actually nothing been advanced which would shake his belief in the conclusions at which he had arrived after a lengthy and careful study of this question. There were, however, a few remarks to which he might be permitted to reply in as few words as possible, lest it might lead to misunderstandings. Mr. Fitzmaurice's contribution was, on the whole, a supplement to his (the author's) paper; with the exception of governing the motor, and with which he would deal more in detail when replying to Mr. Spruson, he entirely agreed with him, and even here he (Mr. Fitzmaurice) came to the conclusion that the rheostat was undoubtedly the simplest and most easily repaired of the two. His remarks about the utilization of the Fitzroy Falls were highly interesting, and he hoped cordially that at some future time this tramway would be constructed, as there could be hardly any doubt but that it would be a remunerative undertaking. Mr. Dickinson's objection to the overhead conductor was merely sentimental, and could be answered perhaps

better in connection with Mr. Elwell's remarks. As his paper was intended to be descriptive of the electric appliances used in "Electric Traction," he trusted Mr. Cruickshank would pardon the passing treatment of the prime-mover, but as that gentleman was a much higher authority on steam engines than himself, he might be allowed to express a hope that Mr. Cruikshank would shortly favour us with a paper on that particular piece of mechanism, which would be highly acceptable to all of us. He thought Mr. Cruickshank might rest quite assured that a higher voltage than 500 would not be proposed by any engineer in connection with street railroading, where, as a rule, no very great distances have to be considered. When it came, however, to electric traction on main lines of railways, currents of higher E.M.F. would, no doubt, be used; but then the danger arising therefrom was reduced to a minimum, as none but employees had any need to come in close proximity to the conductors, and they would soon learn how to take care of themselves. Mr. Cruickshank, in common with Mr. Howe, was under the impression that he condemned the steam tramway motor as used in Sydney. He regretted this exceedingly, as, under the peculiar conditions, they were doing splendid service. This, however, was not the point at issue. What was required here was a three or five minutes' service to the various suburbs, as the public began to growl about having to hang about street corners from fifteen to twenty minutes before getting a tram to their destination, preferring reluctantly to make use of an omnibus, even if they did not reach their homes any quicker. What he wished to convey was—that a three to five minutes' service could not be given by steam motors with the same prospect of profit as with the electric system described in his paper. The question of consumption of fuel and efficiency had already been answered by Messrs. Elwell and Spruson. Regarding Mr. Elwell's statement that his paper was biassed in favour of American practice, this was not the case. The examples quoted by him of English practice were of very recent date, and up to the present had not had sufficient time to prove whether they were a practical success or not. The fact of an underground conduit being constructed in Paris on the Lineff

system was no proof of its turning out successfully, it being purely an experiment. Mr. Elwell was evidently in favour of the conduit system, but he could only repeat what had already been stated in the paper. The difficulties of draining such conduits efficiently, so as to prevent short circuits, under the most unfavourable conditions existing here, were very much greater than would appear without closer investigation. Besides this, the new system of sewerage under construction, not providing for the carrying off of storm water, it would necessitate a special drainage service for the tramways at an enormous cost. In the matter of safety cut-outs for telephone and other wires, Mr. Elwell appeared not to be well-informed on the latest inventions for preventing accidents. Mr. Elwell had his best wishes for the success of the accumulator with which he was now experimenting, and he hoped to hear soon of its having proved itself capable of withstanding the rough usage which tramway service called for. He did not dispute that the cable system could not be made a fair success where the streets were not too irregular, but even then it was his opinion that a good electric system would be more economical. In reply to Mr. Spruson's remarks, the only difference of opinion worth noting was the question of governing the motor. In his paper he had given credit to the Sprague system of showing a slightly higher electrical efficiency than the Thomson-Houston system, but even after Mr. Spruson's elaborate appeal his opinion remained unaltered. This opinion was based not only on the statements of Mr. Whipple and Sir John Fowler; many additional endorsements might be quoted; but he would only introduce one more, namely, the work of Messrs. T. C. Martin and J. Wetzler, "The Electric Motor," with which Mr. Spruson was no doubt acquainted. The authors of this book had been formerly the editors of the *Electrical World*, and were now the editors of the *Electrical Engineer* of New York, and had to be undoubtedly considered unbiassed authorities on this subject. On page 167 we found:—"In the larger type of motors, however, Mr. Sprague prefers to use a rheostat for throwing the machines into circuit, instead of winding the field coils in sections, because it is a much cheaper process of working, and, as in case a heavy machine should be damaged in the sectional

winding, it would be far more costly to make repairs to it than in the case where a rheostat is used. Of course this rheostat carries no current, except at the moment of starting the motor." Again, on page 196, it was stated:—"They are compound wound and provided with Professor Thomson's new winding, in which the main circuit field coils closely surround the armature and oppose the tendency to a change in the line of commutation under varying loads. The machines have, therefore, a constant lead, and require but casual attention when in operation. The efficiency of the motor *per se* is 90 per cent. The current strength employed is 7·5 ampères. The motor will stand thirty ampères indefinitely, and sixty ampères for half-an-hour. Speed is controlled by a coarse resistance in the main circuit composed of iron plates standing on edge. The motor is nearly self-regulating within the limits of its work, and the resistance comes but little into play. This method is preferred to that of changing the strength of the field magnet independently, since the latter necessitates also a change in the lead. The position of the brushes is never changed either for varying load or reversal." In the face of the above evidence the verdict that he had arrived at in favour of the Thomson-Houston motor might be safely claimed to be perfectly justified, and had not been reached without mature consideration. Mr. Nixon would no doubt obtain every information on the points of mining traction, by communicating with the representatives of the various manufacturers of this type of plant. In conclusion, he trusted to have proved to the satisfaction of the members of this Association the statements made in the paper, which would be, doubtless, ocularly demonstrated in a few months' time on the experimental line now in course of erection between Waverley and Randwick. An apology for bringing this question before the Association was hardly necessary, as it was one that had excited such a large amount of interest both privately and through the Press.

SANITARY ENGINEERING AND PUBLIC HEALTH.

J. M. Smail, M. Inst. C.E.

The question of health has been more or less the subject of thought and of legislation from the earliest periods among the ancient Egyptians, Israelites, Greeks and Romans. The *scarabæus* or scavenger beetle was held sacred by the ancient Egyptians.

Under the Mosaic dispensation sanitary laws were formulated and religiously observed. The ancient subterranean works discovered at Jerusalem clearly indicate that the Jews were impressed with the necessity of removing all decomposing matter and filth as expeditiously as possible to places beyond the city. In ancient Rome questions affecting the health of the city were considered as carefully and attended to as assiduously as questions of State policy and government. The existence, after the lapse of twenty-five centuries, of the Cloaca Maxima bears the strongest evidence of the extent to which sanitary science had developed in that early period, the work, rivalling many such of modern date, being still utilised as a public sewer.

Coming to modern periods, the examples set by the Romans were followed more or less in England ; the various old subterranean channels discovered at different times indicate the lines upon which the ancient conduits were constructed. Discoveries have been made in excavating for buildings at Chester that the early Romans were acquainted with the art of making pipes for sewers. In the twelfth volume of the "Transactions of the Institute of Civil Engineers," it is recorded that specimens of red unglazed pipes were exhibited, which, from the inscription on them, were believed to have been laid by the Twelfth Roman Legion. In the

chapter of historical notes in Mr. B. Lathan's work he states that, "although these ancient examples of sanitary works were executed when art and science had reached a high degree of excellence, we come to a period in history when both art and science declined, and with them the prosecution of those sanitary works which were of so beneficial and useful a character; in fact, the benefits derivable from sanitary science seem to have been forgotten and ignored, and the people sunk to the lowest depths of sanitary neglect, from which the powerful voices of plague, typhus, and cholera were the first to arouse them."

Dr. Lyon Playfair, in his address at Glasgow in 1874, stated that "when the civilization of the Egyptians, the Jews, the Greeks, and the Romans faded, the world passed through dark ages of mental and physical barbarism. For a thousand years there was not a man or woman in Europe that ever took a bath. How different that time was from the times which preceded it, when daily baths were common among the poor, you may gather from the praises of personal ablution which abound in ancient authors."

It is to Great Britain we must look for the first country to initiate reform in public sanitation, and the inception of the investigation which has lead up to the development of sanitary science in the present day may be taken as dating from 1847, when the first compulsory Act of Parliament was passed in connection with the disposal of fæcal matter and organic wastes from dwellings in London. It was not, however, until the passing of the Local Government and Public Health Bills that any decided steps were taken in empowering local councils or vestries to make bye-laws, &c., for the proper regulating of sanitary matters in connection with the various centres of population.

In the opinion of authorities on the subject, after nearly thirty years' experience, permissive legislation has proved to be practically useless for attaining the object for which it was granted; this opinion not only exists in England but on the Continent of Europe, and especially in America.

Public opinion has lately become more alive to the consequences attending on sanitary neglect. In a paper read by

Professor H. Robinson, M. Inst. C.E., before the Association of Municipal and Sanitary Engineers, he states that "the thinking part of the community will now appreciate and support any legislation which has for its objects the amelioration of the conditions of the poorer classes, and the enforcement of those laws which are essential for the sanitary well-being of the people. It is a fact that in may respects even the existing mild legislation is not put into operation." Again, he states, "a great amount of preventible mortality arises from houses being occupied which do not conform to the most elementary rules of house sanitation. Those who have had to examine into the cause of epidemics will support the statement which we make, that there exists throughout the country a large amount of house property from which the landlords should he prohibited from receiving rents, and which should be condemned as unfit for habitation." The foregoing remarks have been quoted because they bear directly on the subject of this paper, and we have not far to travel in this city and suburbs to find causes for similar statements.

Sanitary legislation in the colonies has been piecemeal and permissive in its application. The principal Acts passed in the early days of the colony were chiefly connected with the prevention of sale of diseased meat and adulteration of food, and it was not until the passing of the Sydney Sewerage Act (17 Vic. No. 34) in 1853, that any practical steps were taken towards improving the sanitary condition of the city with regard to carrying off the organic waste of the community by underground sewers.

This Act repealed a former enactment passed in 1850, and provided for the appointment of commissioners who were to carry out the provisions of the Act in lieu of the old City Council, which was dissolved by Act of Parliament. The Act invested the Commissioners with certain compulsory powers, which it would appear had never been enforced. After about four years control of civic affairs the Commission was dissolved, and the present City Corporation (20 Vic. No. 37) was inaugurated in 1857.

The Council completed the scheme upon which the Commissioners were engaged, and during the succeeding years the

system was extended to almost every street in the city. The extension of the system and gradual abolition of the cesspit has undoubtedly favourably influenced the death rate of the city. The legislative powers under which the Council operated were of a permissive character, so that they were not in a position to accomplish better sanitary results than they would have otherwise done if compulsory powers had been enacted. Subsequent to the City Corporation Act, the Municipalities' Act was passed, which empowered the Suburban Council to carry out municipal works, and to pass bye-laws for regulating the sanitary affairs of the borough. This Act might be termed the first instalment of Local Government. Various other Acts connected with the sanitation of the city and suburbs, notably the "Dairies Act," and "Nuisances Prevention Act," and, in connection with regulating the construction of buildings and condition of existing tenements, the Building Act and Sydney Improvement Act have been passed. All these measures have materially contributed to the general health of the city.

A Commission was appointed to enquire and report on the best means of supplying the city and suburbs with an improved system of water supply. This was forced upon the Government of the day through the inadequacy of the Botany supply to meet the requirements of the daily increasing population. The result of the labours of this Commission, after careful consideration and enquiry, was the adoption of the present supply from Prospect. This magnificent work has been successfully carried out by the officers of the Harbours and Rivers Department. The available supply being equal to any possible demand for years to come. The effect of having such a supply has materially conduced to the health not only of the city, but also of the suburbs. On the completion of the work the Water and Sewerage Act (43 Vic. No. 32) was passed in 1880, and the whole of the question of water supply to the city and suburbs was transferred from the Government and the City Council to a Board partly nominated by the Crown and partly elected by the ratepayers in the city and such of the suburbs as are supplied by water from the conduit. The Act gives such powers to the Board

as to compel the use of water from the mains by householders, thereby causing the disuse of water from wells for domestic purposes. That the existence of the new supply has contributed in a marked degree towards the reduction of the yearly death rate is beyond a doubt.

The next step taken towards improving the sanitary condition of the city was an enquiry by Commission as to the best means to adopt to intercept the sewage of the city which discharged into various parts of the harbour. The state of the foreshores at the various sewer outlets became so foul and dangerous to health that it was deemed absolutely necessary to divert the daily sewage to some point remote from the densely populated centres. The results of the enquiries and considerations of the Commission resulted in the new system, now nearly completed as far as it affects the city, and making considerable progress in connection with the suburbs. This work was carried out by the Government Sewerage Department, and on its completion was handed over to the Board of Water Supply and Sewerage before referred to. In order that the new system could be extended to the "crowning point," the house service, an Amended Sewerage Act was passed in 1889 (53 Vic. No. 16), the provisions of which are now being carried out by the Board.

In contradistinction to the previous Sewerage Acts, the provisions are compulsory as to carrying out of house drainage, ventilation of private and public sewers.

The Sydney Improvement Act, passed in June, 1879, for better provision in the construction of buildings, and for the safety and health of the inhabitants within the City of Sydney. This Act provides for the proper construction of all buildings erected within the city boundaries, also for inspection of tenements which are deemed unfit for human habitation. Extensive powers are given to the Mayor, the chief administrator under the Act, to deal with any building which is inimical to the safety and health of the public—these powers have been exercised by the different Mayors with considerable advantage to the sanitary condition of the city. The Act is an important addition to the sanitary legislation, and it

is a matter of regret that it was not made to apply to the adjoining suburbs. If the principle of the Act were applied to erection of buildings in the suburbs, the present anomalous state of things would not exist. This defect will no doubt be covered by the proposed Local Government Act. The Sydney Improvement Act further provides for the appointment of a Board which is charged with the hearing of appeals against the decisions of the officers appointed to carry out the Act, and is empowered to determine any question involved in such appeals. The operation of this Act has been the means whereby numbers of hovels and similar disease-breeding spots were swept away to make room for larger and better constructed buildings. Since the passing of the Act in 1879 the improvement of the city has been marked. It might with truth be said that the old city is fast disappearing and giving place to the new. The buildings are constructed with some regard to sanitary laws with regard to light, space, and ventilation; but much has yet to be done in guarding the community from the effects of impure air, which causes fever and lowers the vitality of the occupants, if it does not destroy life itself.

The sweeping away of small tenements and the occupation of the space by larger premises brought to light a singular fact in connection with the buildings in the city. Shortly after the passing of the Act, viz., in 1880, the number of buildings within the city boundaries was given at 25,000; five years afterwards, viz., in 1885, there had apparently been no increase in number. It would appear, therefore, that no buildings had been erected during the above period, but such was not the case, buildings were erected. In many cases the new erections occupied areas formerly occupied by numbers of small tenements, and the absorption of the land for trade requirements accounts for the apparent non-erection of buildings.

The effect of the administrative powers conferred by the Act, and carried out by those charged with the duty, has been conducive to improving the sanitary condition of some of the older sections of the city and lowering of the annual death rate. It is obvious that had the powers been otherwise than compulsory, such result could not have been achieved.

The scavenging of a city is an important adjunct in the maintenance of health. The Municipal Acts impose certain obligations on the residents in keeping their premises clean and free from nuisance; but the enactments do not provide that the corporate bodies shall collect the household waste and other putrescible matter of one portion of the community and dispose of it in such a manner as to be inimical to the health of another portion. This is practically what is being carried out daily. We see low-lying ground utilised as "tips" for house rubbish and other filth, and in all probability the land so raised in level will form the site of future terraces or suburban villas. If compulsory legislation is needed in any direction, this is one where the effect will be most salutary. The provision that all local bodies shall dispose of the household wastes by other means than by reclaiming or raising low-lying lands would lead up to the question which must come in the near future, of disposing of such waste matter by *fire*. As communities become more dense, the dangers to health increase; and it should be the aim of governing bodies to minimise such dangers as much as possible. The destructor is the natural complement of every sewerage scheme, and until the improved means of disposal is co-existant with the sewerage system, only partially favourable results can be expected in connection with public health. Great improvements have been made in this branch of sanitary engineering, the objectionable features of the older designs of the "destructor" having been eliminated by the complete destruction of the vapours given off by the refuse when in a state of incipient burning as well as the arresting of the lighter particles of unconsumed material which, owing to the fierce draught, were rushed into the shaft and had the effect of salting and peppering the surrounding locality.

Compulsory legislation in sanitary matters has been in existence in New York since 1881. Professor Robinson, M.I.C.E., in a paper on "Sanitary Legislation and its Enforcement," remarks that "In 1881 an Act was passed to secure the registration of plumbers and the supervision of plumbing and drainage of

the cities of New York and Brooklyn. This Act was the outcome of a public movement which was set on foot by those who appreciated the evils attendant on defective drainage work and plumbing. Amongst the most prominent of these reformers, and the one to whom the passing of the Act was chiefly due, was Mr. Henry C. Meyer, the proprietor of the *New York Sanitary Engineer*. The powers which the Board of Health of New York have been granted by the State with reference to tenement houses are of the most sweeping kind, and are as clearly defined and capable of easy enforcement as the law relating to plumbing and draining.

The absence of a Public Health Act from the Statute Book of this colony is to be regretted. If such enactment had existed the evils arising from sub-division and sale of land in situations totally unfitted for residential areas would not have presented themselves. It is an established fact that some sanitary measures can only be carried out by compulsion, and the enforcement is not altogether unaccompanied by friction between the administrators and some portions of the public, which are not aware of the benefits derivable from the carrying out of such measures. Each householder considers his house to be his castle, and any interference from the sanitary authority as an impertinence; there is another section who views with alarm the institution of reforms, and consider their interests jeopardised when the authority steps in between them and the public.

With regard to the interference of public authority with private interests, "it has been laid down as a fundamental rule that wherever the public health is concerned the interference of public authority is proper and justifiable." Mr. A. G. Henriques, barrister-at-law, and Hove Commissioner, states: "he ventures to submit that the proposition which he has laid down is true and universally accepted. It has received the assent in all times of statesmen and publicists, and has been throughout the whole course of history followed in practice under every aspect of civilisation. The public health has ever been regarded as so important and so essential to the public welfare that the interference of the State

with private right in order to promote public health has ever been the rule rather that the exception." He further remarks that "private effort and enterprise will surely continue to exist, notwithstanding the small amount of State control involved in the interference of sanitary supervision of dwellings. Private right will be as much respected, and private initiative be as energetic *after* the State has undertaken to control the direction of the drains and formulate the thickness of the walls. Private right will not be injured, but private wrong will be prevented. The ability as well as the opportunity to inflict private wrong will undoubtedly be taken away, but the power to do rightly and act justly will remain as clear and free as ever. The restrictions which the State will impose will be burdens on the evil-doer—on the scamping workman and on the jerry builder—but the honest builder or tradesman will not be interfered with, except as regards some general plan, which he will readily adopt, and to the requirements of which he will conscientiously conform. He will benefit by the destruction of his ill-doing rivals, and the public will benefit by the possession of that which they seek, that for which they stipulate, that for which they pay their money, but which at the present day they rarely obtain—a healthy, honestly built house. There will be a State guarantee of the *desiderata* of good construction. Fraud will be, if not impossible, exceptionally rare; deception will cease to be the rule, the public health will undoubtedly improve, and the principles which will underlie these much desired changes is one often quoted, and rarely controverted: "*Salus populi suprema lex.*"

The foregoing remarks can be applied with equal force in connection with the insanitary mode of construction of buildings adopted at the present time in our suburbs, and even in the city prior to the passing of the City Improvement Bill. The character of the dwellings erected by speculative builders in our suburbs at the present time, is ample evidence of the necessity of the extension of the provisions of the Act which affects the city to the suburbs, or empowering the local bodies to make bye-laws which would tend to correct the abuses now of daily

occurrence. Numbers of houses, of various classes, are being erected in the different suburbs on sites utterly unsuitable for dwellings, unless previously underdrained. In some instances the areas have been for years the receptacle of the sewage and flood-water of the adjoining uplands, the subsoil being thoroughly saturated with filth; and in this description of soil houses are being erected without any means being taken to prevent the miasmatic vapours arising through the dwellings.

The mode adopted, and the materials used in constructing the dwellings, is anything but calculated to contribute to the general health of the occupants. Inferior concrete, porous bricks, and timbers cut down to barest dimensions, no attempts at ventilation under floors being the rule. The buildings are made showy, and everything done to please the eye, and—*sell the building*. In fact, the purchaser gets the maximum of show and the minimum of health and comfort for his money. This is no exaggeration; it can be seen by visiting any of the suburbs, and is the result of the absence of controlling authority for regulating the construction and drainage of such dwellings. To the poorer classes the want of this legislative protection is of some import; the wealthier classes are not so much affected, as they are in a position to command the services of an architect to protect their interests. The Borough Councils not being vested with powers to make bye-laws in this direction, it points to a remedy, which, in the interests of public health, should be supplied without delay.

From a sanitary view the drainage of the site and impermeability of the foundations are most important points in house construction, as it has been proved that damp subsoil tended to promote phthisis. Dr. Bowdelch, of Boston, says: "Private investigations in Europe and America have in these latter times proved that residence on damp soil brings consumption; and second, that drainage of the wet soil of towns tends to lessen the ravages of that disease." In 1865-6, the British Government instituted an examination into the effect of drainage works on public health. Twenty-four (24) towns, several on the modern

system, were examined. From the returns it was shown that the yearly death rate was reduced, and the reduction in number of deaths from consumption was marked.

In a return given by the City Health Officer (Dr. Clay) in his quarterly report to the City Council, the number of deaths from phthisis was forty-five, or 8·39 per cent. of the total number of deaths. Other respiratory diseases, thirty-six, or 6·61 per cent. of the total number; it would be interesting to know the local conditions of the localities where the deaths occurred. Such information would be an unerring guide for the application of preventive measures. The total deaths from typhoid and other filth diseases is given as 72, or 13·24 per cent. of the total number; the application of locality test would be as serviceable in this case as in the former. Dr. Ashburton Thompson, Deputy Medical Adviser to the Government, in a paper on the "Sanitary State of New South Wales," gives the number of deaths from typhoid and diarrhœal diseases in the Metropolitan District, for the year 1884, at 700, or at the rate of 25 per 10,000 of the population. The average for ten years, viz., 1875 to 1885, is given at 26·17 per 10,000 of population. These numbers include deaths outside the limits of the city, and are no doubt considerably influenced by cases from districts which are not sewered, and are exposed to insanitary conditions. Within the city the records as given by the City Health Officer show that for the quarter ending 28th February, 1890, the total number of deaths from typhoid and other filth diseases amount to 71, or 47 per 1,000 of population.

In one case, we have (in 1884) 700 deaths, and in another (1889) within the city boundary, an average of 284 deaths from preventable diseases.

The general death rate of a city is a guide to its healthiness or otherwise, but for preventive measures detail statistics are required of the locality and general surroundings where deaths occur from zymotic diseases; these are more prevalent where there is overcrowding or insanitary conditions. In the city there are certain localities, the surroundings of which are more conducive

to a higher death rate than others more favourably situated; to take the mean death rate of the two is not a true guide as to where preventive measures should be carried out.

In the city the returns of 1888 show the estimated number of dwellings at 21,437, and miles of sewers at 60 miles. With few exceptions, the whole of the dwellings are either connected with the public sewers or drain into the harbour by private ducts. The whole of the old city system, constructed at various times from 1857, is unventilated by public ventilators, but the gases generated in same find vent through other means, which will be explained.

Professor Kerr, in a lecture before the Society of Engineers on "Foul Air in London Houses," said: "The popular idea of drainage is very simple; you empty the slops into the sink, and they go—the devil knows where." This statement could be applied to the drainage of the majority of houses in the older parts of the city. Numerous old drains, the lines of which have been forgotten, have been in the past utilised for conveying the slops and waste water from dwellings; the lateral branches have been added to from time to time, until a perfect network of pipes is available for carrying the mephitic gases from the old and unventilated ducts to the dwellings connected thereto. What is generally recognised as the city system, that is, the system initiated by the City Commissioners, is wholly unventilated, except in cases where the street gullies happen not to be trapped. As this system was designed on what is termed the "combined system," and the outlets being exposed to tidal influences, the conditions are such as to cause them to be "sewers of deposit;" the organic filth which accumulates from time to time in dry weather in the sewers generates dangerous sewer gases which find vent where?—through gully-shafts at the side-walks where they are not trapped, or oftener through the house drains, thence into the houses by the agency of defective sanitary fittings. You cannot bottle the gas up. It would be no exaggeration to say that the old city system is, to a very great extent, ventilated by the house drains. The effect of this system of ventilation on the health of the community can readily be imagined. Through the absence of proper ventilation

sewer gas finds its way into dwellings, not only of the poorer classes, but into superior dwellings. Examination by the officers of the Board of Water Supply and Sewerage has revealed a state of things in connection with the sanitary fittings of private and public dwellings which would appear incredible, if not supported by actual fact. A few cases which came under the author's notice will be mentioned to illustrate the danger to which the public are exposed: 1st. In what might be termed a first-class dwelling, the waste pipe from a bath was connected into a soil pipe from a W.C. The soil pipe from this W.C. was not ventilated, nor was there any intercepting trap between house and public sewer. The closet trap became choked, and the fœcal matter found its way through the bath waste pipe into the bath. In another case, in a building where a large number of persons are employed, the overflow pipe from a cistern from which the drinking water used by the employés was drawn, was connected directly with an unventilated soil pipe, which carried off the soil from W.C.'s, urinals, etc. The evil was aggravated by the fact that there was no trap between the sewer and soil pipe. The cases mentioned are comparatively mild and are a few of the many, clearly showing the absolute necessity of supervision by a controlling authority, and the futility of permissive legislation. Under the Corporation Act the City Council were not vested with powers that they could control the supervision of internal sanitary plumbing work and ventilation of drains, although there are evidences in the buildings of later date, where my colleague, when acting as City Engineer, has carried this into effect as far as the legal powers at the time would admit.

Under the powers granted to the Board, which now controls the water supply and sewerage, the defects referred to are gradually being remedied as they are discovered. Under the Act not only the carrying out of the work, but the plumbers and drainers are under the immediate control of the Board. In this way the interests of the public and competent men are protected against ignorant and incompetent workmen, who have in times past acted on their individual ideas of sanitation.

Dr. Carpenter, in his address before the Sanitary Institute of Great Britain on "Public Health as a Working Man's Question," says "that according to the reports of your officials the mortality of some parts of Glasgow has been 50 and 60 per thousand in the course of the year. Do you know what that death rate means? It does not mean simply that so many people have died; for every one who has died 20 have been laid in beds of sickness in the course of the year. For every one who has died in a healthy district—I take my own district—there has been two on an average on a bed of sickness every day throughout the whole year. Now, if you will only consider that point you will see that the bearing of the death rate of a district has immense influence upon the prosperity of working men."

This question concerns the working classes here as well as in Great Britain, a reduction of the death rate implies also a reduction in sickness, and consequent saving of expense and money. This point leads up to the consideration of the advisability of obtaining statistical information as to the sick rate from various causes in different sections of the city and suburbs.

The number of sick cases to deaths is variously stated. Dr. Carpenter gives 20 cases for every death; Dr. Playfair, 28. Taking the lowest estimate and comparing it with the returns of the City Health Officer for last year, the amount of sick cases from preventable diseases equals 1,440 in one year.

The proportion of deaths from typhoid and diarrhœal diseases, given in a table connected with a paper read by Dr. Ashburton Thompson before the Australian Association for the Advancement of Science, is 2·5 per 1,000 of population. The mean population of the metropolitan area for the period given in the table, 1876 to 1885, is 225,460; and the number of deaths from preventable diseases is 565 per year or 5,650 for 10 years. Taking the estimated cases of sickness for each death, as before-mentioned, viz., 20, we have $5,650 \times 20 = 113,000$ cases of preventable sickness in 10 years. Although we individually consider life as priceless, yet it is obvious that if preventable measures are adopted such as would result in the saving of so many valuable lives and

immunity from sickness, not only would the State be benefited but individuals also.

If a value could be put upon lives so saved and sickness prevented by preventive measures, the above results could be summarised as follows :—

Lives saved, 5,650 at £200	£1,130,000
Sickness prevented, 5,650 × 20 = 113,000— taking the average duration at 5 weeks' say at £1 per week = 113,000 at £5 ...	565,000
5,650 funerals at £5...	28,250
	£1,723,250

Nearly sufficient to pay the interest on the public debt of the colony, or sufficient to pay for the cost of the new sewerage system.

There is one branch of sanitary work in which practical knowledge is especially necessary, and which has not been so prominently considered or attended to as it should be, and this is the plumbing work of houses. However carefully an architect may design your house the whole may be rendered nugatory by scamped work and carlessness in details. The traps may be fixed in such positions as not to fulfil the end for which they are intended; the junctions with the drains may be faulty; the soil pipes may be to all appearances perfect, but they may not be connected with the drain or may ventilate into the house. It is easy to conceal a bad joint, and it is some time before the defect is discovered; the discovery, as a rule, is made when sickness if not death occurs in the house. It is, therefore, not only the officers of the sanitary authority who require knowledge and to be educated in this important branch, but also the foreman and workmen each in his own degree.

Waring, in his work on "Sewerage," says, with regard to house drainage, that the general public in America seems to have formulated its convictions somewhat as follows :—

1. No house drainage is really good which has not the approval of the family plumber.

2. Unlimited expenditure in the plumbing work ensures the safety of the house.
3. The public sewer is the root of all evil.

The Sanitary Engineer cannot interfere with the general conditions of a climate, but he may produce important changes in the immediate surroundings of a locality, modify the conditions and temperature of the soil under the air-power, and provide a supply of pure water. He may also provide for the rapid carrying off of organic wastes and rainfall; but it is to the physiologist and chemist that we must look for the causes from which the epidemics or diseases arise, and what are the conditions which should be altered to prevent or remove them. The engineer steps in when the causes have been pointed out, and it is for him to design the methods of prevention or removal.

The diagram, Plate VIII., shows the annual death rate, rainfall, and mean temperature of the city of Sydney from 1871 to 1889. It will be seen in comparing the lines the points of death rate and rainfall in some cases approach each other in proportion to the rainfall.

In conclusion, it is to be understood that whatever progress science may make in the discovery of the causes of epidemic diseases; and, however completely the authorities may seek to carry out preventive and curative measures founded upon such discoveries, it rests in the end with the people to say whether such discoveries and preventive measures shall be productive of good. All the discoveries of science and all the care of the authorities will avail nothing if the people themselves are careless in matters of house sanitation and domestic hygiene.

DISCUSSION.

Mr. Trevor Jones remarked that the paper read by Mr. Smail had evidently been prepared, not so much to provoke discussion, as to disseminate and promote the latest views entertained by sanitarians upon the sewerage question, and he (the speaker) was at one with him on every point that had hitherto shown itself. He observed that Mr. Smail had sought to show up the utter valueless character of permissive legislation, and its inadequacy to procure any sanitary improvement. While in the service of the Corporation as City Engineer, he had a large experience of the powerlessness of this form of law. For instance, it was permissible for any citizen to adopt the highest science in the ventilation of his premises; and some did so, acting on advice, but whilst their neighbours did not also adopt the same measures, the sanitary citizen found that flues set up by him discharged sewer gas in too strong doses over his own roof, partly relieving the sewer (and his neighbours', no doubt), but at his own cost, as well as to the concentration of the foul air in his own locality. If, however, the law had been such as to enable the City Council to enforce the erection of shafts against houses in sufficient numbers, then the gases discharged at any one of them would be so diluted as to cause no nuisance, and the sewer would be relieved of foul air as it was evolved. The Council, however, being powerless, and also being about to be deprived of the control of the sewers, had no strong inducement to enter on legislating for the same. Finding the uselessness of permissive laws, he wrote a paper containing the substance of all that he had then (1883) read, and thinking to

obtain the help of some public body to further the cause, he secured a reading of it before the Health Board, but with the result that it had never seen daylight since. He then re-wrote much the same paper with such additions as he could, demonstrating the futility of all systems in vogue for voiding the foul air from sewers, except the vent-flue system, now advocated by, and being carried out by his colleague, Mr. Smail, and read the same before the sanitary section of the Royal Society. The daily journals gave favourable notices of the paper, but that was the sole issue; indeed, little else could be done then, for at that time the germs of the present system were being prepared for Parliament. Among people who had not had any great experience in the treatment of sewer air, the notion of which the column at the end of Bathurst Street was an example, was very popular; indeed, up to very recent years, it was given the credit of answering every purpose. The believers in that system theorise that the gas, being lighter than air, would, by its lesser specific gravity, tend to rise, and would flow upwards along the crown of a sewer towards such a column to the summit, in the same way as water flowed along the invert by gravity toward the lower extremity. Experimenters, however, arrived on the field, and applied the touchstone of test to the theory, and they were disappointed to find that the total effect of such a shaft was restricted to a distance of 300 feet, and that parts of the sewer beyond that distance were not influenced by the shaft in the least degree. If, therefore, such columns were to be of any use in liberating the gas, it would be necessary to have one at every 300 feet of the length of the sewer; the absurdity of such a system required no proof. There were those, who still advocated the placing of gratings over the top of the sewers at frequent intervals along the middle of the street, pointing out that by having a great number, the gas that would arise would be so dilute as to be harmless. Experience had always demonstrated the failure of this system; if, indeed the principle of thorough dilution with air would be effectual, why had covered sewers been introduced? why not let the sewage run in the gutters? Feeling

his powerlessness while in the Council to insist on ventilation generally and universally, he did the next best thing possible, viz., to so design such sewers as were laid under his direction, that they could be easily convertible into ventilated sewers, by insisting upon the introduction of a ventilating disconnector trap at the building line where the sewer was under the house, or elsewhere where circumstances demanded. In conferring the large powers on the Board of Water and Sewerage Board that the Legislative Assembly and Council had done, they had established a power that would before very long render this city such as to be second to none in the world for the salubrity of its air; of course, he also referred to the suburbs about to be treated. The Board was seconding in every practical way the efforts of its officers to bring about the above consummation.

Mr. J. B. Henson said that the first part of Mr. Smail's paper was an historical sketch, from which it would be seen how the art of sanitation, like many other arts, had had its periods of progression and decadence. Happily for us, the art was at present in a progressive stage and had reached a point of efficiency which had, so far as was known, never been equalled. Mr. Smail had given most prominence to that branch of sanitary engineering which had to deal with the sewerage of cities and towns. The supply of pure water was of equal, if not of more importance, and many of the water supply works of the ancients still existed, monuments of their knowledge and skill. Water supply and sewerage works had jointly by their beneficial results transformed many of the old European cities and towns from veritable plague spots to a high degree of healthiness. The death rate in London in the last half of the seventeenth century was eighty in every thousand; now it was about twenty-four in every thousand, although much more densely populated. At Dantzic, in 1865, the death rate from enteric fever per 100,000 was 108; water supply and sewerage works were introduced, and in 1880, the record stood at eighteen. A study of the recorded results that had followed immediately upon the adoption of well-considered sanitary precautions showed sudden drops of from twenty to thirty-three

per cent. in the death rate. An idea of the original condition of some of the localities operated upon could be gathered from the following extract :—

" . . . . Sanitary progress in Great Britain is recent, and the first rude sewers were more mischievous than beneficial. The earliest Norman castles were not sewered, but were sinks of filth both within and without. One of the earliest improvements was the guardrobe turret or tower, constructed in an external wall, the floor being carried over the outer face on corbels. This floor was dished from the sides to a central opening from which excreta could fall outwards to the base of the castle wall. Some of these guardrobe towers were removed from Windsor Castle since 1840. About the beginning of this century water closets were re-invented and were introduced into better class residences, the drainage from them being to the nearest sewer, or from the house to some ditch or watercourse or to a pit, or even over the surface of the ground or into the side-channel of a public road. In London and some other towns the nuisance arising from water-closets was found to be so great that Improvement Acts were obtained, in which clauses prohibiting a use of public sewers for water-closets were inserted. The old sewers were large, rude in construction, irregular in gradient, having flat bottoms and being unventilated, so that every form of refuse passed into them remained to putrify, ferment, and exhale gases of a deadly strength ; and on some occasions men on entering to cleanse them fell dead. The comfort and convenience of water-closets having been experienced, parties using them did not like to give them up ; and, as they were not to use the sewers, they were ordered to construct absorbing cesspools into which the contents from the water-closets were to be emptied, and cesspools were constructed within the basements, yards, and gardens of London houses by tens of thousands, some larger houses having several. In course of time an overflow from a cesspool, cesspit, or ashpit, was permitted to connect to a sewer."†

† Extract from "Report of a Committee appointed by the President of the Local Government Board to enquire into the several modes of treating town sewage, London, 1876."

But whilst water supply and sewerage were the two chief branches of sanitary engineering, and were accredited with the production of the greatest benefit to a community, there were numerous minor, but nevertheless important, branches, such as food supply, ventilation, warming, lighting, scavenging, subsoil and surface or rain water drainage. All these demanded attention, and, receiving it, produced the best results, and led towards the attainment of the acme of sanitary achievements—pure soil, pure air, pure water and pure food. It was not usual, however, to regard the sanitary engineer as a person charged with the direction of all these various branches. An American writer had called him a "scientific scavenger," which name would no doubt be thought to be very fit by the general public. Sanitary engineering had not made the progress in America that it had in the United Kingdom, but during recent years public attention had been aroused, and there was no doubt that now the Yankee had got a firm grip of the subject he would bring it to an issue (as he generally did with his undertakings) second to none. The following quotation would show how the subject was likely to be handled, thus:—It was taken from a report of Mr. O. W. Wight, to the Common Council of Detroit, Mich.:—"The soil where man dwells is sacred, and it is sanitary sacrilege to pollute it. He who fouls the air that he breathes himself, or the water that he drinks, or the food that he eats, is a barbarian who might learn wisdom from the cat, or decency from any swine not demoralized by contact with man. He who fouls the air that another must breathe, or the food that another must eat or the water that another must drink, is a criminal, to be classed with those who maim and kill." These words were worth remembering, and applied equally well to the actions of communities. Several years ago when the land mania was raging, he, the speaker, read the prospectus of a company among the advertisements in the *Sydney Morning Herald*. The land to be operated on was situated at Marrickville, and contained some deep clay pits and a brick yard in working order. It was pointed out that there was an abundance of clay and of great depth; the excavations could be used as a tip for the rubbish of the

neighbourhood, and when levelled up, the surface could be sold for building purposes! He did not know whether the venture was a success—the company only intended to do what unfortunately too many private individuals had done, and were now doing in and around the city and suburbs, and not only individuals, but municipal authorities also on a much larger scale. The legacy for the future inhabitants of the sites was physical weakness, disease and death. The continuance of the disposal of the refuse in tips was criminal, and could not be justified in any way. In a paper he had the honor of reading before this association a few years ago, he drew special attention to the necessity for a special treatment of the main lines of natural drainage, and the adjoining low-lying ground. Nothing could well be done unless special legislation was obtained. This was still a great want, and the sooner the want was satisfied, the better it would be for the present and future generations.

Mr. E. W. Cracknell considered the subject under discussion of great importance to the general public as well as to the members of this Association, and should claim more than ordinary attention While thoroughly concurring with the author's statements, he (the speaker) wished to make the following comments on his valuable paper:—

The ruins of ancient cities showed that sanitary engineering was one of the oldest branches of our profession, and though the works of the ancient Romans existed to this day, proving that they possessed a considerable knowledge of sewer construction, sanitary matters were neglected from the fall of the Roman Empire to the middle of the 19th century, about which time municipal authorities in most large cities became impressed with the necessity of attending to these important matters; large sums of money were spent, chiefly in constructing sewers; modern engineers introduced many sanitary improvements, and though Governments had made laws to protect the public health, the sanitary branch of our profession was still in a most unsatisfactory state, for a glance at the proceedings of the Institute of Civil Engineers would show that a great difference of opinion existed

among engineers on several very important sanitary matters. When we remember that the London sewerage was dealt with by a Royal Commission in 1884, and the question supposed to be settled by the sewers being carried further down the river and provided with sludge tanks and arrangements for precipitating with lime and sulphate of iron, the effluent to be discharged below low water during ebb tide and the sludge taken to sea or used as manure; and that there appeared in a recent number of *Engineering* (April 11th, 1890) an article stating that the disposal of London sewage was again exciting public interest, and proposals are spoken of, one of which was to carry the sewage some 46 miles further, discharging into the North Sea. The present unsatisfactory state of the Thames seemed to prove the following remarks of Dr. A. Pfeiffer, of Wiesbaden, which were taken from vol. 93 of the Proceedings of the Institute of Civil Engineers, page 540. It was there stated :— "That it would not be possible to render the effluent so acid or so alkaline that no bacteria could continue to exist therein, because fish would be destroyed in the rivers, and the waters would be rendered useless for domestic and economic purposes. Before the influence of bacteria was so well known as it now is, it was thought all sufficient if the effluent from the sewage after treatment with lime, magnesia, alumina, or salts of iron, was rendered clear to the eye, whereas it is no longer a matter of doubt that this clarification is only a treacherous mask, and that, as the food-stuffs of the bacteria remain in the water it will soon again decompose and become filled with these organisms. It must then be evident that no chemical treatment can comply with the requirements of modern science."

From the above there did not seem to be much hope of a satisfactory solution being arrived at by the chemical treatment of sewage.

The results obtained from sewage farms varied in different localities, and must depend very much on the nature of the ground and the management of the farms.

Many of the difficulties in dealing with sewage had been attributed to the fact that storm waters were usually admitted,

which varied the sewage and diluted it to such an extent that it was difficult to treat in any way, especially on a sewage farm.

Without going into the merits or demerits of the separate and combined systems of water carriage, he might state that the former had been in operation in the City of Denver since 1880, and was started at Memphis before that date, but he had seen in an extract from the City Engineer's report of the City of Denver for 1887 that the time had arrived when the present outfall would have to be carried two miles further down the stream. From which we might reasonably infer that a nuisance existed at the outfall.

The foregoing remarks showed that the disposal of sewage was still a vexed question which engineers must solve before the water carriage system could be regarded as complete.

Another unsolved problem was the disposal of sewer gas which was formed, especially where soil pipes were connected with the sewers, for no matter how rapidly the sewage was carried to its destination, more or less sewer gas would be found, which, in the best regulated systems, found its way into the air a little above the house tops where it contaminated the atmosphere, and must render the upper stories unhealthy in thickly populated localities, more particularly where the height of the houses varied. These remarks also applied to Liernur's system for ventilating pipes carried up from the pans which were trapped with fœcal matter, the vacuum only acting once in twenty-four hours.

The decrease of the death rate in the City, and corresponding increase in the suburbs, was rather misleading, for this was partly due to the much-abused trams and railways, which enabled those at business in the City to live in the suburbs; and, though many might be poisoned by unhealthy surroundings while in the City, they went home to die, thus unfairly increasing the suburban death rate.

The disposal of city refuse was a subject mentioned by the author, and though he (the speaker) agreed with his remarks, he thought a few facts bearing on this important subject would not be out of place. From the Corporation returns for last year, he found that there were 103,966 loads of rubbish removed from

the City, exclusive of dead animals. If we deducted the sand and mud, we have 90,732 loads of putrescible matter, together with the following dead animals:—23,327 dead fowls, 2,762 dogs, 7,007 cats, 43,014 rats, 660 goats, 147 rabbits, 42 diseased dogs, 20 monkeys, 2 pigs, and 1 native bear.

The above, compared with returns of rubbish collected in English cities, showed that there was considerably more rubbish produced per head of population here than in England, and an examination of the refuse removed from houses here proved it to be much more offensive, as it contained considerably more animal and vegetable waste, which was probably accounted for by the hot climate and more plentiful supply of meat.

The present system of depositing this enormous mass of putrescible matter in the outskirts of the city, adjacent suburbs and public parks, must materially increase the suburban death rate, and prove injurious to the public health. Some of the localities in which this matter was deposited were Sydney Common, Moore Park, Pyrmont, Camperdown, Rushcutter's Bay, Waterloo Park, and the Centennial Park. One of the largest of these tips as they were usually termed was situated behind Mount Rennie, with one entrance in Dowling-street, and one from the Randwick-road, beyond Moore Park. This entrance had an agricultural appearance, and at first sight might lead anyone to suppose it led to a dairy farm, provided the wind was from the north-east. After passing through a wooden gate, and walking a few hundred yards, the nuisance arising from the tip became unpleasantly suggestive. The higher parts of the ground were composed of refuse in various stages of decomposition. The lower parts were shallow water holes, or swamps into which refuse was tipped. On the occasion of his visit to this spot, the noxious vapours and swarms of flies prevented him from closely examining the more modern parts of this interesting locality. Men were busy burning the more inflammable refuse, while others were collecting articles of value, but he noticed several dead animals, and having smelt more than he cared for, he made for the nearest sandhill, but before reaching it, found himself in the nightsoil department, through which he

picked his way carefully, and, reaching the summit of the next sandhill, found himself in the model suburb of Kensington. The top of the sandhill was being removed to fill the low lying parts. Streets were curbed, guttered and formed, and though the sewage was being attended to, he should not care to reside in this, otherwise pleasant locality. After his experience in reaching it, he should not think the distance more than a quarter of a mile from the worst part of the tip, and the effects of a hot westerly wind, or a sultry summer night could be better imagined than described.

During last summer, large portions of the Centennial Park were manured with refuse, which not only emitted noxious vapours, but produced swarms of insects which invaded the houses for some distance round the park. Towards the end of the summer, he saw by the newspapers that in one month there had been 46 cases of typhoid in the city and suburbs of which 23 were in Waverley and Randwick. As these suburbs adjoined the park, these facts would speak for themselves. Most sanitary authorities agreed in saying that putrescible matter should be destroyed by fire, and about 30 years ago furnaces were erected in several English towns; but on account of their faulty construction many had to be abandoned. Since then several patents had been taken out, and the results of past experience, together with careful attention to the laws of combustion, had overcome all difficulties in dealing with this matter, and all city refuse could now be burnt to ash and hard clinker, without smoke or nuisance of any kind.

The author pointed out the necessity of a Public Health Act, and as this matter had been talked of in Parliament, we might reasonably expect some legislation in this direction, in view of which he thought the members of this association should fully discuss this important subject, as we could not expect statesmen to make satisfactory laws on matters of this kind, unless we as engineers informed them what could be accomplished by modern engineering.

Mr. Haycroft considered the paper more valuable from an historical than from an engineering point of view. No doubt, as

pointed out by Mr. Smail, the Act should be extended to the suburbs. It was in existence in the City and had done a great amount of good, and would have ten times the scope of doing good in the suburbs. As regarded the licensing of plumbers by the Board, though he thought it very desirable, yet he had found it in many cases inoperative. He had known of cases in which licensed plumbers had employed their unlicensed apprentices to do the work. Perhaps the Board could see some way of compelling apprentices to pass an examination, or else make a master keep a strict eye over them. There was one point connected with the public health that was not touched on, and that was the absence of public urinals in the streets of Sydney; and, indeed, in the suburbs. It was a vital point connected with the public health, and its neglect was a disgrace to a city like this, which claimed to be in the van of civilisation.

Mr. Cruickshank stated that his knowledge of sanitary engineering was very limited, but he had listened with a great deal of pleasure to the gentlemen who had spoken on the subject. Mr. Cracknell's statistics about the dead animals reminded him of what he read a short time ago about the old Romans, who were remarkable for their cleanliness. But he had also read a remarkable expression by an eminent doctor, who stated that after the decline and fall of the Roman Empire, nobody had a bath for a thousand years.

Mr. Smail, to the various remarks, said he felt exceedingly gratified at the reception accorded to his paper. It gave him the greatest pleasure to advance our calling in every possible way he could. He did not pretend to be a philanthropist in trying to advance the good of his native city; but he might say that for very nearly twenty years he had studied this question, and with the magnificent climate, and other advantages we possessed here, he could not see why the death rate of our city should not be even less than that of the healthiest city in the world—London. We had a system of sewerage here instituted thirty years ago. For the last eight months he had been burrowing under Sydney, and it had been a perfect marvel to him that the death-rate had

been so low as it had, considering the existing state of things. He thought every engineer, whether in the metropolis or the suburbs, would agree that, unless the powers conferred upon the municipal authorities were compulsory, all their efforts for good would be rendered nugatory. Outside influence was brought to bear, and the fact of the matter was, that the engineer, who ought to be the person to deal with the matter, had his opinions ignored, on account of individual interests, and the community suffered. Mr. Henson had touched upon another important branch of sanitary engineering —viz., the water supply. He had mentioned that in his paper, and acknowledged that with a proper system of sewerage, a water supply would cause a reduction of the death-rate. Mr. Cracknell had treated us to a very statistical and amusing description of Moore Park. He had not exactly the pleasure of investigating that locality himself, but he perfectly agreed that the obnoxious manner of disposing of house refuse was likely to be dangerous to human life. Mr. Haycroft touched on certain matters regarding urinals. While agreeing with him, he (the speaker) might point out that it would be absolutely impossible to touch upon every detail in sanitary engineering in one paper; at the same time, it must be acknowledged that this matter was a disgrace to the City. In other cities these conveniences were to be found everywhere, either gratis, or for a small fee. Another matter Mr. Haycroft had referred to was the licensing of plumbers. This was one thing they did claim credit for. They had a number of licensed plumbers who did plumbing work under proper control. The fact that licensed plumbers employed their apprentices to do the work did not militate against the system; for how could an apprentice become a capable plumber unless he assisted in the work. But the man who held the license was made responsible for the work, and it was a fact not generally known that a person who employed a plumber, need not pay him until he produced a certificate from the Board inspector that the work has been properly carried out.

14th August, 1890.

DELTA METAL:

ITS HISTORY, PROPERTIES AND USES.

By Walter Reeks.

The subject the author has the honour of bringing under your notice to-night is, he ventures to believe, of importance to all those engaged in engineering work, whether civil, marine, or mining. To the marine engineer whose attention is constantly directed to the all-powerful enemy—rust. To the mining engineer, who as often finds himself called on to cope with acids and foul air, both the sworn foes of iron or steel in any form. And to the civil engineer for both reasons. He thinks he is safe in saying the mean temperature of the sea over which our coasting steamers run is fully 5° above that on the English coast, and something like 13° above the mean in the North Atlantic and round the east coast of the United States, and if that be admitted it follows that the tendency to rust is very much greater, and the value of a material that will effectually resist rust proportionately higher. Presumably the water in mines is not affected by depths, but due to local causes, and the effect of copper and lead on iron with water as a medium is too well known to need comment from me.

A metal, then, that will not rust, is practically impervious to the action of acids, as strong as steel, amenable either to being cast, rolled, drawn, spun, or forged is found in Delta metal, of whose properties more anon.

The terms bronze and brass are frequently used in a very indefinite manner, so much so that many people consider them one and the same thing. True, it is very difficult to know where to draw the line; but, generally speaking, bronze is technically understood to be a mixture or alloy of copper and tin, while brass is an alloy of copper and zinc.

The word copper is derived from Cyprus, whence it was first obtained by the Greeks.

Tin has been known from the earliest ages, and is synonymous with Bedril in the Hebrew language. Tin was known 1,500 years antecedent to the commencement of our era.

Many writers of repute maintain that zinc was unknown before the Thirteenth Century, but Dr. Percy quotes authorities who agree that the Romans at least were well acquainted with this metal, and used it in the manufacture of an alloy, to which they gave the name of orichalcum, similar to that we now term brass.

Lead was known to the ancients alone with copper and tin. It is worthy of note, however, that the use of lead for water reservoirs was considered so objectionable that it was strictly forbidden by Hippocrates, Galen, Vitruvius, and others.

When we read so frequently, as we have done of late years, of lead poisoning, we cannot help coming to the conclusion that in many respects we are not so very far in advance of the old Romans, after all.

We have ample evidence that the Chinese were well up in the preparation and manufacture of bronze and other copper alloys at a very early date.

Delta Metal, which is now so well-known in the engineering world, is the outcome of the researches made by Mr. Alexander Dick, with a view to improve the ordinary brass—that is to say, the usual copper and zinc alloys.

Much has been done, and with good results, during the last decade to improve the bronze—that is, the copper and tin alloys, but no endeavours have, to the author's knowledge, been made to improve the qualities of the common brass, or copper and zinc alloys.

The author might mention, however, that about twenty years ago Aich and Baron Rosthorn, of Vienna, made a series of experiments, in the course of which they tried various proportions of iron in the copper-zinc alloys, and arrived at results which at first promised a higher degree of success than was ultimately attained.

These results, as tabulated by Dr. Percy, show that the alloys possessed the properties of tenacity and strength to a remarkable extent, but the great drawback seemed to be the want of uniformity in the composition of different castings produced from the same alloy, even when the greatest care was taken in the manufacture.

About twenty years ago, while engaged in the management of extensive brass works on the Clyde, Mr. R. Macintyre made numerous experiments with a view to making gun metal into which certain percentages of iron should be introduced. After giving the matter a fair trial, as he thought, he was unable to see where any decided advantage was gained, and so let it drop, but it was not till some years after, when comparing the experience of Aich and Rosthorn with his own, and looking at the success which Mr. Dick had achieved, was forced to the conclusion that he, at least, had been on a wrong track in trying to obtain the alloy by melting the iron in the copper.

Following up the researches of Aich and Rosthorn, Mr. Dick says his first object was to ascertain the cause of such uncertainty in the results. He produced various quantities of the alloy, in accordance with the Austrian method, but found the results varied in each lot, from the fact that the quantity of iron could not be accurately controlled. Such being the case, the next step was to find a method by which a known or definite quantity of iron could be introduced, and this he succeeded in doing, by dissolving the iron in the molten zinc to saturation, and then adding a known quantity of this compound, with or without pure zinc, to the molten copper. In consequence, however, of the partial oxidation of the metals during the process of re-smelting, by which the castings again varied, Mr. Dick found it necessary to introduce a

small proportion of a deoxide, such as phosphorus, etc. Being thus enabled to introduce a definite proportion of iron in the alloy, it was only a question of patiently making and completing a long and costly series of experiments to ascertain the most suitable compositions of alloys possessing qualities to suit the widest range of applications, for it will be readily understood that in practical working, the manufacture of a great variety of alloys is a very great inconvenience. The Delta Metal Company, Limited, who work Mr. Dick's patents, now produce alloys differing widely in their qualities; but as it would occupy too much time were he to deal with them in detail, he will therefore confine his remarks more especially to that quality of Delta Metal which is known as No. 4 alloy. He might mention here, that the word "Delta" has been adopted by Mr. Dick for a trade mark, in order to somehow connect his products with his name, Δ (Delta), as you are aware, corresponding to the letter D in the Greek alphabet. In this connection it may be mentioned that, though the variety of alloys made or sold by the Delta Metal Company, Limited, seems considerable, it does not necessarily follow that all are under Mr. Dick's or any other patent, but simply that they are the Company's products.

The Delta No. IV. alloy, which, on account of its great strength and resistance to corrosion has by far the largest sale of the various alloys produced, can be forged hot for pump rods, valve spindles, propeller shafts, cranks, boiler stays, and a variety of other purposes. Objects made of Delta Metal instead of gun metal or brass, can be much reduced in weight while the strength is retained. A highly interesting series of experiments has lately been made by Professor Unwin, who tested the various alloys at high temperatures. If we consider that steam at the ordinary atmospheric pressure, has a temperature of 212° Fahr., we shall be led to see how boilers and fittings, working under higher pressures, will be affected by the correspondingly higher temperatures. Boilers being, as a rule, supplied with cast brass cocks and copper tubes, the question naturally arises, are these materials the best suited for the purposes for which they are

employed? The tests referred to were made by Professor Unwin, to ascertain the tensile strength of metals at various temperatures, and the results are as follow:—

BREAKING STRAIN TONS PER SQUARE INCH.

	Rolled.			Cast in Sand.			
Temperature,	Copper.	Yellow Brass.	Delta.	Brass.	Delta.	Phosphor Bronze.	Gun Metal.
Atmospheric.	17·84	24·09	31·16	12·45	23·89	16·06	...
210°	17·41	...	...	...	...	...	11·66
258	...	22·44	...	...	...	...	...
260	...	...	28 30	...	...	...	...
270	...	...	...	...	...	14·16	...
300	16·43	...	...	...	...	...	...
310	...	...	...	...	23·36	...	...
350	...	...	...	11·83	...	12·26	...
380	...	...	...	...	...	...	12·26
400	...	21·23	26·58	...	...	...	...
406	...	...	...	...	...	...	11·06
410	15·95	...	...	...	22·48	...	...
430	...	...	...	...	...	12·41	...
440	...	...	...	...	...	...	12·30
450	...	...	...	10·40	...	...	...
500	15·09	18·33	23·83	7·69	...	11·10	7·84
506	...	...	...	...	19·68	...	...
550	...	...	...	7·68	...	...	...
570	...	...	19·32	...	...	...	...
590	...	...	...	...	16·00	...	...
600	14·30	15·86	...	...	...	8·17	5·22
615	...	...	...	...	...	...	4·82
635	...	...	...	...	12·70	...	...
340	13·70	14·49	...	...	...	..	...
645	...	...	...	3·23	...	...	...
650	...	...	16·04	...	...	...	...

The bars were turned down in the middle over a length of 2in. to a diameter of $\frac{1}{4}$in. or $\frac{5}{16}$in. and were fixed in an oil bath heated by a gas jet. Delta valves used for compressed gases were

formerly cast in gun metal, but there was always the greatest difficulty in obtaining them sufficiently sound to avoid the gas passing the metal, so enormous is the pressure to which they are subjected. Now in Delta No. IV they are simply hot stamped. This stamping costs less than the casting of gun metal and not a single one of these stampings, of which many thousands have been supplied, has been found to leak or to be otherwise faulty, thus saving a great deal of expense, as any fault in such valves is generally found out after a great deal of labor has been expended upon the same. The sample of Bevil wheel stampings will illustrate the advantages of Delta stampings over gun metal castings. They require no cutting of the teeth; as you will see they come out perfectly, and besides this, they possess double the strength of cast gun metal. The sand castings of Delta No. IV. possess equal or even greater strength than best wrought iron, and amongst many uses of such castings the gearing for the Swiss Mountain Railway (Rigi and Pilatus), where the safety of the passengers completely depends upon the strength and soundness of these wheels may be mentioned.

"For testing the strength of each casting separately, a test bar was formed with the pattern, moulded, and cast along with it in one piece. The bars were then cut off, and tested by Professor Tetmayer, of Zurich, the results showing a tensile strength of from $21\frac{1}{2}$ to $23\frac{1}{2}$ tons per square inch, with an elongation of from 40 to 30 per cent. on a length of $7\frac{7}{8}$ inches. Besides these tests, the constructor of the Pilatus Railway, Captain Locher, had the following direct test made:—One of the Delta Metal pinions having been in use for a long time, the teeth had worn off about one millimetre, so that their thickness at the root was $\frac{5}{8}$ inch, and at the top $\frac{7}{16}$ inch, by a breadth of $4\frac{7}{8}$ inches. It was tested to show what power would be required to break such a tooth, the strain acting upon it under unfavourable conditions such as it in reality never experienced.

The pinion (Plate IX., Fig. 1) was put in the testing machine between two clamps, P, acting on the entire breadth of the top of

the teeth. The test, made by Professor Tetmayer, gave the following results :—

P	5	9	10	12	14	15	16
L	0	0·015	0·019	0·059	0·098	0·133	0·169
P		17	18	19	20	21	21½
L		0·208	0·244	0·295	0·354	0·472	(broke)

P indicating the stress in tons, and L the shortening in decimals of an inch of the distance L originally measuring 2¾ in. Both as regards P and L the results were unexpectedly favourable."

The quality which Delta Metal No. IV. possesses of not corroding—a property which is due to part of the copper being substituted by iron—has introduced its use largely for sanitary purposes, as, for example, Kent's Water Meters, which are completely made of Delta; Maignen's Filters, in which the taps, air pipes, and other portions used to be made of brass, are now made of Delta Metal. Sir Frederick Abel selected Delta Metal for water bottles and other vessels used by the troops, on account of resistance to corrosion.

Delta Metal finds, so far as weight goes, its largest application in marine engineering for propellers, pump rods, and also for the building of the hulls of ships and torpedo boats. A number of the latter have been entirely built of this alloy, and a 60 ft. launch is on the stocks at Messrs. White and Sons, Cowes, Isle of Wight, while an electric launch is being built by Mr. Sargent, of Chiswick, for Baron Rothschild. A boat has been constructed by Messrs. A. F. Yarrow and Co., of Poplar, for the German Colony in Central Africa. The plates and angles are of Delta Metal, and the stern, keel, and propeller are forged of the same material; and in order to facilitate the transport, it is constructed in sections which can be easily put together. Another large launch is now being built, also in sections, it being specified that no piece should weigh more than 60 lb. The advantage gained by using Delta Metal instead of steel in the construction of these launches is that, whilst it possesses the same strength as the latter, and can thus be made

of same thickness of material, it is practically incorrodible, which becomes of great importance in countries where skilled labour cannot be obtained, and where steel and iron hulls rust through in a very short time unless continually painted. The price of the finished launches is stated to be from 20 to 25 per cent. more than that of similar launches built of steel; but, taking into consideration that Delta always retains its value, it is maintained that the Delta launches are the cheaper.

Delta Metal is admirably adapted for use in gunpowder works and powder magazines, as it does not emit sparks when subjected to shocks. For torpedoes it affords the requisite strength with the minimum of weight. The interior parts of the Whitehead torpedoes, and Mr. Lege's patent torpedoes, the wire reel, spindles, and other parts of the Brennan, are made entirely of Delta Metal. At the Artillery workshops of one of the leading continental Governments, Delta Metal is being tried as a substitute for gun metal for wheel naves, and other parts of gun, ammunition, and ambulance carriages. The results of experiments made so far have been of a highly satisfactory character.

The four columns forming the legs of the Eiffel Tower are each composed of four standards resting upon cast iron shoes The upper part of these shoes is bolted to the standards, while the lower part enters a cast iron bed-plate to some little depth, thus forming a hydraulic press upon which a pressure of 800 tons can be exerted to adjust if necessary the level of the different parts. The hydraulic pressure is supplied by pumps, of which the cylinder, plunger, and valves are of Delta Metal. These pumps having to support a pressure of 3·5433 tons per square inch to ensure the working power of 800 tons on each standard, have all been tested to 700 atmospheres.

The ironclads "Marceau" and "Pelayo," the former of the French, the latter of the Spanish Navy, have been provided with hydraulic rammers—for the charging of the projectiles—made of Delta Metal, solid drawn tubes, working telescopically one into the other by means of hydraulic pressure. The construction of

the apparatus was carried out under Special Survey, none of the tubes being accepted before having been submitted to a severe test. Some of these tests were as under :—

Diameter outside. Inches.	Inside. Inches.	Thick. Inches.	Bursting pressure. Tons square inch.
$2\frac{1}{32}$	$1\frac{13}{16}$	$\frac{7}{64}$	2·2225
$1\frac{19}{32}$	$1\frac{15}{32}$	$\frac{1}{16}$	2·8575
$4\frac{11}{16}$	$4\frac{5}{16}$	$\frac{3}{16}$	1·524
$4\frac{11}{16}$	$4\frac{5}{16}$	$\frac{3}{16}$	1·746

Among other hydraulic tests the following may be mentioned:—

A solid drawn tube 5·2in. outside diameter, and 0·098in. thick, having a circumference of 16·39in., was subjected to a pressure of one ton per square inch, at that pressure the measured deformation on the circumference was only 0·0492in. Another tube 4·7in. outside diameter, by 0·19in. thick, the deformation at the same pressure was 0·063in., but only temporary, and disappeared as soon as the pressure ceased.

Resistance to Shock.—Blocks of Delta Metal and of bronze (the latter of the composition used in the French Marine), both $1\frac{3}{16}$in. thick, and weighing forty-four lbs., were dropped from a height of one metre (3′ $3\frac{3}{8}$″) on a punch $\frac{9}{64}$″ section. The result was the following :—

	Delta Impression. Inches.	Bronze Depression. Inches.
1st blow	0.025	0.04
4th ,,	0.046	0.095
7th ,,	0.06	0.129
10th ,,	0.078	0.151

Compression Test, by Mr. W. H. Stanger.—Delta metal forged cylinder diameter outside 1.255in. inside 0.758in. area 0.786 square inch.

Limit of elasticity ... 34.85 tons square inch
Maximum Stress ... ... 52.99 ,, ,,
Percentage of compression : 21.4 per cent on 1.306in.

Other crushing tests were made at the Royal Testing Laboratory at Berlin with pieces of rolled bar, 1.189in. diameter area 1.11 square inch. One was tested to 61.404 tons per square inch ultimate, and another to 61.278 tons square inch.

A steel chain with one cast Delta link in the middle, diameter of links $\frac{5}{16}$in., was tested to over 35 cwt. when the last steel link broke. The other steel links were all considerably deformed, but the Delta link alone resisted without the slightest deformation.

RESULT OF TEST OF CAST DELTA METAL CHAIN.

Description.	Stress. Tons.	Under Stress. Inches.	Extension Permanent. Inches.	Remarks.
Delta Metal Chain cast in sand, diameter of link 0.733in.	2.176	.070	.01	
	2.544	.1	·03	Appearance of fracture. Yellowish grey close and uniform.
	2.946	.2	.1	
	3.381	.3	.25	
	3.616	.4	.34	
	3.870	.5	.43	
	4.040	.6	.53	
	4.285	.7	.62	
	4.464	.8	.72	
	4.665	.9	.81	Complete fracture at root of link (several links partly fractured.)
	8.147	2.8	.—	

Ultimate—19.3 tons.

The above chain was a portion of one of those supplied to the Brazilian armour-clad turret-ship "Riachuelo."

The length tested was ten feet.

Molesworth gives 4 tons as the working load of $\frac{3}{4}$-chain cable and test load as 10.1 tons; therefore Delta metal cast chain is practically as strong as wrought iron chains for ordinary ships' cables, as actually stronger than galvanized chain.

The most recent test was made by Mr. Stanger on the 24th October last, as follows :—

TENSION TEST OF CAST DELTA BAR.

	Inches.	Per cent.
Diameter	0.611	
Area	0.293	
Reduction in area		20.1
Extension on	4	20.5
Extension on	2	21.
Extension on	1	21.
Limit of elasticity		11.54 tons sqr. in.
Maximum stress		23.89 ,, ,,

Sound fine grained fracture.

Machron gives 16 tons for gun metal, and only 8 tons for cast brass, and for wrought iron only 22 tons.

The following is an extract from the *Engineer*, 15th July, 1887 :—

" CORROSION OF METALS IN MINE WATERS.

" The Bonafacious Coal Mining Company, in Westphalia, having much trouble from the acid waters quickly corroding the iron and steel of their underground machinery, made a series of experiments with a view to finding the relative corrosion of metals of suitable strength. Brass and gun metal are not strong enough, and trials were made of steel, iron and DELTA METAL. Rolled bars of each of these were immersed during a period of six and a-half months in the water issuing from the pits at Kray, and then carefully re-weighed and photographed. Plate IX, Fig. 2. The bars were of 7.5" long, and had a sectional area of 0.62 inch. The following are the weights of the three kinds of bars before and after the trial. In consequence of the rapid corrosion of iron and steel, DELTA METAL is now being used instead for underground machinery in this and other mines.

	Wrought Iron.	Steel.	Delta Metal.
	lb.	lb.	lb.
Weight of bars when put in	1.1805	1.2125	1.2787
After 6½ months ...	0.6393	0.6614	1.2633
Loss	46.3%	45.45%	1.2%

COMPARATIVE TESTS OF DELTA AND MUNTZ METAL, BY PROFESSOR SCHOFFEL, OF VIENNA.

Round rolled and drawn bars of each of the two metals were tested in a solution of salt, results as under:—

	Rolled.		Drawn.	
	Muntz.	Delta.	Muntz.	Delta.
	millimetres.		millimetres.	
Diameter of bars...	18½	20½	19½	20½
Length of bars ...	50	50	50	50
	square millimetre.			
Surface exposed to corrosion ...	2960	3286	3223	3286
	kilo.	kilo.	kilo.	kilo.
Weight of bars ...	0·103	0·1385	0·1252	0·1385
	gram.	gram.	gram.	gram.
Loss in five consecutive trials ...	8·11	5·69	7·79	5.67
Loss per cent. ...	7·88	4·11	6·22	4·10
Appearance of surface	Wrinkled and undulated cracks.	Smooth and uniform.	Wrinkled flaws and cracks.	Smooth and uniform.

In August last (1889) the author ordered a sample lot of about 5 cwt. in ingots, billets, bars, plates and anglebars; and having a yacht building at the time, where the owner wanted everything as neat and natty as possible, he decided to use Delta fittings entirely about the decks.

In designing the fittings a reduction in the diameters of all eyebolts, chain plates, etc., of 20 per cent. was made, being the margin usually allowed for the deterioration of iron due to galvanizing.

The chain and runner plates on which of course all the heavy strain of the mast comes, together with many of the hooks and block-straps are of Delta, and have done their work right well, so far not even a sign of wear can be detected.

DISCUSSION.

Mr. Houghton (a visitor) stated that it was about five or six years ago since his firm first took up this Delta metal. One of the advantages was that they had no special trouble in forging it. It was a most reliable metal, and was not affected by corrosion. It was equal to steel in strength.

Mr. Cruickshank did not consider that there was much to discuss, because what Mr. Reeks had put before us were facts. He (the author) had proved that this metal was very much superior to anything yet introduced. With regard to the many bronze mixtures which had been tried, he (the speaker) had had experience of them in marine work, and some had been good, some bad. No doubt Delta metal would, in a short time, be used for many purposes for which iron and steel are used at the present time. With regard to that which specially recommended it, its non-corrosive quality, we all knew the great difficulty in contending with corrosion in steel. It was a problem that had puzzled every practical man. We did not know what to do with it, more especially when exposed to salt water. Corrosion in steel was much more rapid than in iron.

Mr. Sands asked whether it was possible to braze "Delta" metal.

Mr. Reeks: Yes.

The President said that it was evident from the remarks which had been made that "Delta" metal would be extensively used in the future in engineering work, though he did not mean to say it would supersede gun metal or ordinary brass.

11TH SEPTEMBER, 1890.

DANGERS ARISING FROM THE USE OF CERTAIN CLAYS IN EMBANKMENTS, DAMS, ETC.

BY ANGUS MACKAY, F.C.S.

IN complying with the request of the Council of the Engineering Association, that the author should submit a paper upon the changes that occur in certain clays, when used in embankments, dams, etc., and with special reference to the share taken by him in overcoming the dangers that during last year threatened the great reservoir dam at Prospect, it was cause for regret to him that he was unable to prepare and read such a paper at an earlier date. But, there is now available for professional purposes, the very able and exhaustive papers submitted to Parliament by the engineers who had charge of the investigations made at the request of the late Minister for Works, the Honourable John Sutherland, and which includes the evidence given by the author, and also chemical analyses of earths and clays which were the cause of the trouble. That paper is ample, he believed, for professional purposes, yet he willingly complied with the request of your Council to bring the subject still more fully before the Association with the view of getting at details that may be of use—of immense practical usefulness, he has no doubt—to the profession in dealing with clays of the Wianamatta series, as substances in the formation of earthworks, embankments, dams, etc.

That the result of our investigations may reach the points which seem to him of most importance, we must, at the outset, define the character and nature of clays much more closely than

is usual in the general acceptance of terms which class clay as that species of earthy matter which is ductile and sticky, in contradistinction to the looser or more sandy earths which are free or comparatively so from the properties mentioned. There are very many characteristics in clays additional to what may be termed "plastic," "sound," "meagre," "pipe," or "brick" clays, "faulty," "spewy," "slurry," "rotten," etc., etc. Clays are, in reality, amongst the most intricate of earths, their qualities are not to be got at by off-hand casual examination. In some most important particulars they differ from the general laws which appear to regulate the behaviour of inorganic and organic substances. Thus, most bodies expand by heat, and contract by cold. The clays we are concerned with reverse this very general law of nature; they contract by heat. Then, they are enormous absorbers of water. Some of them will take up and hold over twice their own weight of water after drying. In the case of some of the clays examined at Prospect, which he was assured were quite dry, they were found to hold over 30 lbs. of water per cubic foot. These clays have the further property of dissolving water, and absorbing the oxygen that it contains, thus bringing about changes which alter their nature, and what is of still more consequence in an embankment or dam, increasing their bulk and lowering their powers of cohesion. By drying a clay in the open air, and observing its behaviour and the changes that occur from contact with the atmosphere and rain, its appearance when rubbed, whether gritty between the teeth and similar tests, a good deal can be learned concerning it. Such investigations may be sufficient when moderate masses of clay matter have to be moved in order to form embankments. But when great masses of material of the kind have to be changed from the beds where they lie in the state of nature, and then placed in position where absolute solidity is required, and the mass has to resist the heavy sudden pressure of loaded trains, or the still more disturbing influences of moving masses of water, it seemed to him a serious responsibility to go on with such work without the more definite examination which is reached only by minute chemical analyses.

It was not his purpose, in this paper, to enter upon any lengthened disquisition concerning either the general formations or the chemical composition of clays. They are very various. Those with which we are immediately concerned—the clays of the Wianamatta shales and the Hawkesbury sandstones series, are dealt with, possibly to a sufficient extent, in the analyses submitted by him concerning the Prospect dam. In addition, he might add that other clays he had examined are composed of alumina (or true clay matter), silica, iron in various forms, water, and sulphuric acid; others contain no iron; and others contain potash, as much as 6 atoms per 100. Pure clay is by no means plentiful. An immense field for investigation is opened by examination and analyses of N. S. Wales clays, some of which are rich in the wonderful metal aluminium, and which might well make us hope for such a discovery, at no distant date, as would bring that immensely valuable metal into general use. But, for the purposes of the investigation with which we are at present concerned, the following report, submitted to the Minister for Works, and which appears at pages 71-2 of the Parliamentary Paper mentioned, may prove ample:

Technical College, Sydney,

31st December, 1888.

Re Prospect Dam.

Dear Sir,

As coming within the scope of investigations I have been making into the soils of the colony, considerable attention has been given to the nature of the clay and soil used for forming the puddle-wall and for making up the sloping embankments of the Prospect Dam; and as I now feel certain of having discovered the cause of the fretting away or weathering of the material used in the earth-work, and the consequent alarms which have arisen concerning the safety of the whole structure, I take the liberty of submitting the following for your consideration.

You will see that the cause of disturbance is more of a chemical than a mechanical nature.

On examination of the stuff used for building up the earth embankment on the reservoir or inside slope of the work, I find it to be made up very largely of a peculiar species of clay, common to the Wianamatta shale formations of the metropolitan district. This clay is largely composed of silicates of iron, and is acted on rapidly and visibly by exposure to air, rain or water. It shrinks in bulk as a first change, it then cracks and oxidizes rapidly, changing to yellowish and reddish clay loam, of a character different essentially from the original clay. These are some of the chemical changes that occur, as I have had frequent and minute occasion for observing in connection with the cultivation, trenching, and draining of the Wianamatta shale soils—the clays especially, for orcharding and other purposes.

The mechanical effect of the chemical changes have become very visible at the Prospect Dam works. As the shrinking and oxidation proceed, the silicious or sandy portion of the clay matter tends downwards, it being very much the heaviest; while the oxidized and loamy portions of the clay earth become so lively, especially when saturated with water, that they float or wash away. This is, in reality, what has been going on at the Prospect Dam, ever since water was brought into contact with the clay soils of the inside slope of the work; and the process must continue to go on until the oxidation and chemical changes are complete, and the soil settles down into regular loamy strata or layers.

The question then is, how can these consequences be met? And this, I have not a doubt, will be found a much less troublesome matter than at first sight appears. It will be seen that if any extra heavy material, such as stone, is placed on top of earth undergoing the chemical changes, and under the conditions mentioned, the result will be to press out the lighter portion of the material—which analyses, in this case, let me say, is nearly one half of the whole—the stone sinking downwards by the displacement. Where the soil is in contact with water, as in the case where slips outwards have occurred at the Prospect Dam, the process is very rapid, the light stuff being literally spewed out upon the water,

where it is forming ugly blemishes upon the magnificent proportions of the huge earthwork.

I would suggest that, as the changes going on in the embankment cannot be stopped, the better course would be to meet the alterations as they occur, and so aid in the process towards absolute solidity. This can be done by using water from the reservoir to soak—not to saturate—the soil. This would increase the process of oxidation, the sinkage and shrinkage being met by applying loamy soil, which would be washed into any small cracks or crevices. Large gaps and slips could not occur under this course of treatment. Thus the material of the embankment would solidify gradually downwards upon the solid earth below and against the puddle-wall behind. The said puddle-wall is, to every visible appearance, a most solid and perfect work.

Examination of the whole earth embankment along the inside face of the dam shows that the changes mentioned have occurred most rapidly where the greater proportion of loose clay matter has been deposited, and where the westerly winds have had fullest opportunity for exerting their influences. This is just what might be expected. If all the bank facing the water had been of loamy earth no such rapid changes would have been likely to occur; and it might be worthy of consideration whether, where such masses of material have to be dealt with, it would not be a desirable course to have chemical analyses made, in order to have a knowledge of the changes which must occur when the stuff is moved and placed under different conditions from its natural state. Where clay has to be dealt with, so intricate and obscure is much of it in composition, that investigation of the kind seems to me a very necessary proceeding, to ensure safety.

In order to meet the fretting or weathering action upon the earthwork slope by the water in the reservoirs, when moved into wavelets by the winds, I would suggest that slabs of colonial hardwood—which does not float, being more dense or heavier than water—would answer the purpose of protecting the moving earth below. They could be fastened so as to lie upon, without pressing

or shifting, the material under them ; and as the stuff settled down solid the stone cubes could be laid in position, as being the very best material for the purpose.

I have now the pleasure of submitting the foregoing for your attention and consideration in such manner as you may consider most fitting, either in a private, or public sense. I do not intend doing anything more in the matter. My desire has been to try and help to get at the cause of the troubles at Prospect Dam. The leisure of a brief holiday, and the use of the apparatus in the Agricultural Department here, have made the investigations possible and pleasant. I will be glad to give any further information in my power, either to yourself or to any of the professional gentlemen concerned, whom you may entrust with the same. I will be in Sydney during Wednesday, Friday, Saturday, and Sunday, January 2nd, 4th, 5th and 6th. I leave for Port Macquarie, Monday.

I have, etc.,

ANGUS MACKAY, F.C.S.,

Inst. Agriculture, B.T.E.

The author wishes it to be clearly understood that in all the steps taken by him in connection with the Prospect Dam investigations, he was careful that no reflections should be cast upon any of the professional gentlemen who had been or were engaged in the work ; and this for the simple reason that neither at that time, nor since then, did he consider that blame was attachable to those who had carried out the operations. The changes that were taking place, and the changes especially in the earthwork embankment facing the waters of the reservoir, had all the characteristics of novelty. No such huge masses of Wianamatta clay shales had been moved previously into one work. The alterations going on, therefore, were unforeseen, as part of embankment-forming experiences. His own acquaintance with the clays and other soils of similar formation had been made from quite another direction—that is from the processes of minute examination and analyses of the agricultural chemist, whose labours

lead him into more intimate relations with the nature, composition, and changes in soils, clays, etc., than is considered necessary for the purposes of the railroad or hydraulic engineer. When the alarm concerning the movements in the dam earthworks at Prospect was at its height, the idea caught him that possibly the changes going on were similar in character to those under his observation at that time upon clay soils from near Hornsby, and another part of the same Wianamatta series. So, on his own responsibility, he spent several days about the Prospect works, and being assured that he had got at the cause of the trouble, it became a duty to communicate with the chief of the Department concerned. Hence the foregoing report.

After consultation with his advisers of the engineering branch, the Minister called on the author to give evidence for the experts called in from the other colonies. That request was complied with. The evidence goes over much the same ground as the foregoing report, and appears in full at page 52 of the Parliamentary paper. Then came a further request that he should examine, analyse, and report upon the soils and clays at Prospect in the most exhaustive manner possible. That final report solved the difficulty, he believes, and as it gives the most definite information yet worked out concerning these clays, he offers it in full, from pages 84-5-6, of the Parliamentary paper:

Technical College, Sydney,
28th February, 1889.

Sir,

In response to request conveyed in your communication of January 9th, I proceeded to the Prospect Reservoir in order to get specimens of the clay and other material of which the dam is constructed.

The Engineer in Charge, Mr. Ryan, promptly placed the necessary facilities at my disposal, and by means of auger rods (bores having been put down in parts of the work where the process of disintegration is going on, and again where the stuff has

"slipped" or moved forward by gravitation from its original position in the bank) I got the material dealt with in the analyses as Nos. 2 and 3.

The No. 1 material is the raw unworked clay taken from the bed of the watershed, from which, as I am informed, was got the bulk of the clay for forming the puddle-wall, and a large proportion of the stuff used in the protecting embankment which faces the Reservoir, and which is now in contact with the water.

The No. 4 is the loamy earth which covers and faces the Prospect Quarry, and is of the type of which is formed that portion of the embankment facing the water which has given the least, if any trouble. This latter material is of volcanic origin, it is true; thoroughly oxidized earth that is not likely to move or separate were it placed in masses of any conceivable size. It affords all the properties which should make perfect reliable material for an earth embankment formed on correct lines, and which has to resist disturbing atmospheric effects, or from being in contact with, or possibly saturated with water. This latter material does not alter—in a mechanical sense—on exposure to the weather, air, or water, and is thus the very opposite of the clay material of No. 1.

Plate X. shows from where Nos. 1, 2, and 3 were taken :—

In order to get at the real character of the substances, they have been tested by mechanical and chemical analyses, by microscopic examination, by weight, and specific gravity, with the following result :—

No. 1 Mechanical analysis of clay matter from the Wianamatta shale series—already described in a former report—yellowish-white in appearance, as taken from the natural bed, where it lies unaltered by air exposure. It weighs 165lb. per cubic foot; when dry, 143¾lb. per cubic foot. It yields 31 per cent. of very fine sandy matter which, under the microscope, appears as rounded grains of quartz sand, white in colour, and which weighs 170lb. per cubic foot. 69 per cent. of the whole is very fine silicate of

alumina, plastic, and which, for ordinary purposes, is true clay matter of very fine quality. For making puddle it is not easy to find anything better.

Chemical analysis shows :—

	Per cent.
Moisture of combination and organic matter (the latter fractional)	9·7
Sandy and dry matter, insoluble in strong acid	86·755
Alumina and iron	2·37
Sulphuric Acid	0·11
Lime	0·22
Magnesia	0·12
Undetermined matter (alkaline)	0·725
	100·000

This material, owing to its close density, the weight of other clays over it, and the enormous proportion of fine clay matter present in its composition, would remain unaltered for all time in its natural bed; but, when moved and exposed to the air and the changes of contraction and expansion, arising from drying winds and wet weather, it alters in a remarkable manner, as we see from the next analysis of the stuff (No. 2.) taken from the inner face of the embankment where the "slip" had occurred, and from below the water level in the reservoir.

No. 2 plastic clay-like material, showing reddish veins and streaks. Weight, 172lb. per cubic foot; when dry, 151lb. Masses of particles of hard oxide of iron are visible under the microscope. Oxidation, or separation of the sandy from the fine clay matter is going on rapidly in this material. 14 per cent. of sandy matter separates freely; the remainder, 86 per cent., is coarse clay, coloured by the oxodized iron, and is still undergoing separation.

Chemical analysis shows :—

	Per cent.
Moisture of combination and organic matter	9·31
Sandy and clay matter, insoluble in strong acid	83·257
Alumina and iron (peroxide)	5·857
Sulphuric acid	0·11
Lime	0·23
Magnesia	0·095
Undetermined matter (alkaline mostly) ...	1·151
	100·000

That a great change has taken place in this material, in comparison with the raw stuff from the undisturbed bed below, is very evident. The increase of weight and presence of nearly 6 per cent. of alumina and oxidized iron, show what has been going on and what must go on till the oxidation is complete.

No. 3. Matter got from below the level of the water in the reservoir, and outside of the original slope of the embankment. It is, in reality, part of the stuff that has "slipped," or moved forward, because of the chemical changes brought about by contact with the water in the reservoir, which movement is increased by the pressure of heavy material above.

As taken from the boring tool, it weighs 120lb. per cubic foot; when dry, 96lb.

Further separation gave 47 per cent. of very fine clay matter, weighing 70lb. per cubic foot—which is but slightly heavier than water. This stuff really floats in water for several days before it settles.

It seems very likely that if further tests are applied, and the matter that has moved furthest into the water can be reached, it will be found to be still lighter; indeed, that the mass there is but very little heavier than water, and therefore, most difficult stuff to retain in position in the presence of water in a state of movement—as the case is in the reservoir at Prospect. Under the microscope, it is seen to be a mass of very fine aluminous matter, with but little sandy or silicious stuff.

Chemical analysis shows :—

	Per cent.
Moisture of combination and organic matter	14·50
Clay and sandy matter, insoluble in strong acid	75·10
Alumina and iron	10·00
Traces only of sulphuric acid and magnesia. The lime has all disappeared	.....
Undetermined matter	0·40
	100·00

No. 4. Earth from the surface embankment of bluestone quarry, from which broken metal and cubes are got for facing the inside embankment of the reservoir. This is very decided volcanic material, and which shows the process of oxidation still going on very rapidly in the rock. In the soil the change is practically completed, and hence, that part of the embankment made up largely of stuff of this kind, is not influenced by the weather changes or contact with the water. Mechanical analysis gives 48 per cent. of very fine silicious matter, which the microscope discovers to be coated with oxidised iron. The remainder is fine aluminous earth. As gathered during a dry day, the earth weighs 119lb. per cubic foot. By drying at an even temperature of 212°, 25lb. of water per cubic foot of soil is evaporated.

Chemical analysis shows :—

	Per cent.
Organic matter and combined water ...	22·50
Sandy matter and loss	28·65
Alumina and iron	47·00
Lime	·60
Magnesia	Traces
Chlorine = Salt	·90
Potash	·20
Sulphates and Phosphates	·15
	100·00

Several minute tests were applied to this soil, as also to the others, in order to get at any changes likely to occur by saturation with water. The only observable change in No. 4 was that it gave off distinct traces of chloride = sodium (salt), and magnesia, which affected the water and made it sweetish.

The violent changes observable in connection with Nos. 1, 2, and 3, and which are referred to fully in the former report I had the honour of submitting to your Department, do not affect this earth (No. 4). Hence my reasons for recommending it and other earths in which oxidation has been completed for the formation of such works as those at Prospect, where in process of time the earth facing the water must become saturated.

It will be seen that, when tested closely, the driest of the clays (No. 2), and which in general observation is supposed to be dry, actually contains 21lb. of water per cubic foot.

I think it will be seen by the foregoing analyses that the cause of disturbance in the embankment is due to the character of, and the consequent oxidation of the large masses of clay matter (No. 1) lodged there. When saturated, the heavier portions of the mass separate rapidly and gravitate downward. In the face of any movement in the mass, which may arise from wind, storms and agitation of the water of the reservoir, the movement must be very rapid, and where there is pressure above the mass, either of stone, earth, or lodgments of rain-water, the change will be accelerated, and accounts in full, as it appears to me, for the changes that are going on in the work referred to, and which may have the effect of loosening the puddle-wall behind, by the removal of its supports.

The state of No. 3 proves further that the lighter portions of the material have been pressed, or floated, outward in large masses, thus tending to still further remove the support the embankment was erected to give.

I can but reiterate the suggestion made after the first investigations, and submitted in the former report, that, as oxidation of this huge mass of matter cannot now be prevented, the better course is to humour it, and to encourage the whole mass to settle in natural strata or layers. Oxidation of the character and

dimensions mentioned may be controlled, it cannot be stopped. No human agency can do it; but much mischief may be done by attempting to force this natural manifestation of nature.

In conclusion, I would again suggest the desirability of having chemical examination and analyses made of clay and other materials that have to be moved in masses, in order to make those in charge of the works acquainted with the changes which must take place when such matter is moved and exposed to the influences of the weather under conditions which differ essentially from that of their natural state.

I have, etc.,

ANGUS MACKAY, F.C.S.

In the existing conditions of human affairs, embankment and dam working, the ethics of engineering, chemical analyses, etc., included, it is scarcely to be expected that all of us can agree upon such a very simple discovery as that made by the author concerning the changes that aroused so much alarm for the safety of the Prospect Dam. Personally, he never had a doubt of the safety of the work. It is a magnificent outcome of engineering skill, and a credit to New South Wales; he would be of the very last to detract from the good work done there. It is no ordinary pleasure to add that the efforts made by him were accepted in the spirit they were offered—that was to help rather than embarass during a time of serious public excitement. Of course, in summing up all that had been done, those who drew up the report dissented from some of the conclusions he had arrived at. That was all right, of course, and was expected; but the data was acted on all the same. And there have been no alarms since. The long continued wet weather has been immensely beneficial in aiding the changes going on, and in consolidating the work; and he quite agrees with Mr. Mesteyer, who says, at p. 22 of the report:

"The mechanical action of the water has, I believe, been the principal cause of the movements that have taken place, but the evidence given by Mr. Mackay goes to indicate that this action has probably been much intensified by the chemical decomposition of

some portions of the material, notably the clays, which under the influence of moisture rapidly oxidise, and in so doing increase considerably in bulk. My own observations on the behaviour of these materials when exposed to the influence of water and air entirely confirm this, and the expansion of the clays, due to their chemical decomposition, would call into action a force tending to move the bank bodily towards the water, even if the angle of repose were more than has been provided for. If the movement is due to this action alone it will soon cease, and when that occurs the bank will rapidly consolidate."

In conclusion, the author has not a doubt that the work should stand for generations—a lasting monument of engineering skill in New South Wales. But seeing how little is the trouble and expense attached to chemical analyses, he might add that in future that safeguard should be applied before risking the movements of masses of clay matter heaped up in embankments, dams, and similar works, where alterations in, or shifting of the material may lead to very serious consequences.

DISCUSSION.

Mr. W. Shellshear stated that the nature of the clay in the Hawkesbury series was very well known to many people, and especially a certain white clay, which was used very largely in connection with the Prospect Dam. If a sample of this clay were placed in water, it resolved itself down to the consistency of "spue" or porridge; it had not the power to carry even its own weight under such circumstances. It certainly seemed strange to him that no attempt had been made to ascertain the mechanical qualities of this clay before using it in such positions, and under such conditions, as had been done. At the point where the slip happened, he noticed a large portion of this clay was in a plastic state. Where sand was used, no movement had taken place. A space in which the puddle was placed, was so constructed as to resist the weight of the water, and the clay was only supposed to afford a puddle wall, yet at Prospect the whole of the bank was nothing more or less than one mass of puddle, caused by the employment of this material. If a test like that numbered four in the paper had been made, no movement would have taken place. It appeared to him that sufficient care was not taken to prevent this stuff from getting in. He did not profess to be an expert in dam construction, yet it seemed a mystery to him that such a course could have been taken. His experience taught him that the moment water touched this particular clay, down it went. The remarks made by Mr. Mackay were very interesting, and the chemical change he described was very noticeable, particularly in the red clay. As far as the trouble at Prospect was concerned, he (the speaker) attributed it to this white clay, but the

difficulty could be easily overcome by facing the bank with stone, and he considered that this was the only course that could now be followed.

Dr. Storer stated that in England the question was always to get a fat clay, that was to say, having large cohesive power. Recently a new method of making puddle had been resorted to, and, he believed, with success. Instead of plastic clay, the clay used was well dried and then ground and put in the wall, and, as soon as the water reached to it, expansion took place, and the whole work became perfectly solid. With reference to the aid of chemistry to engineering, a forcible example of this was shown a few years ago in Tasmania, where abortive efforts were made to establish ironworks, and thousands of pounds were squandered, when a chemist's fee of ten guineas would have prevented all this waste and labour. He had no doubt that if a similar thing had been done at Prospect the trouble would have been averted.

Mr. J. B. Henson remarked that Mr. Mackay had referred to the Wainamatta clays or shales. The speaker had given some attention to these clays and all the clays prevalent in the County of Cumberland. These Wainamatta shales at a distance below the surface were laminated, but near the surface they appeared in a form of clay more or less plastic. It was almost impossible to find two parts alike, the percentages of the constituents varying greatly. The deposition of the various substance had taken place in different parts of the country. This might be seen at the Newtown railway cutting, Petersham cutting and at Rookwood. In the cuttings the clay was taken out in blocks, and after a short time these blocks took the appearance of mounds, as the disintegration, due, he believed, to the existence of pyrites, set in. Mr. Mackay explained this as due to the oxidation of the iron. The inference apparently drawn in the paper of the analysis as tabulated, did not seem justifiable to him (the speaker) as the process of oxidation was limited to pure iron. With regard to the presence of sand, he had seen dams in which the materials largely consisted of a red sand and a little clay mixed with it, and he believed these dams were very stable, and where the silica was

so fine that it could be used almost like emery for sharpening purposes. The Wainamatta shales had proved a most interesting study to him, and he was sure they would well repay investigation.

Mr. Poole would have been pleased if the author had shown the essential difference between the Wainamatta shales and similar clays in the mother-country. With regard to the Prospect movement, there could be no blame attachable to anyone. It was apparent that this clay had some unspecified quality which came to the fore when mixed with water. On one of his visits to the dam just after the first serious movement, he took a piece of the material, sun-dried as it was, from above the water level, and laid it on the stone face of the dam, and in an hour the piece, which was originally as large as his two fists, had resolved itself into a fine sludge. It was certainly strange that some simple test had not been made to ascertain its stability for the purpose required. The construction of the dam was without doubt heavy and massive, but it was simply a large piece of earthwork with a puddle wall running through it. If the outer face had been constructed of the same material as the inner face there would have been no movement.

Mr. Seaver had not seen the Prospect dam, but he thought the bank could not have been made in layers. In many specifications it was stipulated that the tramways should be lifted and laid at different places. In Ireland, the whole earthwork of the last construction he was engaged upon was laid about two feet at a time. It appeared strange to him also that no authoritative test had been made with the clay used in the dam. The first thing to be looked to by the engineer or contractor was to find out what the clays were like. The Johnstone dam in America was made in the same way as the Prospect dam appeared to him to have been made.

Mr. Fischer: The dam was made in layers.

Mr. Haycroft thought Mr. Mackay's paper had more value from a chemical point of view, than from an engineering standpoint. He had had some experience of earthwork, but this was the first time he had heard of a water face being formed of clay

in the body, although the puddle wall at the back was, of course, formed of that material. His idea was that clay should enter into the puddle-wall, and be buttressed by the two sides. The same material being used on the outer face was not so important. No doubt it was open to atmospheric influences in that position. He had recently visited the dam, and he could see no cause for any anxiety regarding its stability.

Mr. Salmond had been on the works several times during their progress, and he might say the work was carried out in a perfectly satisfactory manner, the only point being the unfortunate selection of the clay. The clay was to be selected material, and the engineer was very careful. There was no tram laid down, but the bullock teams were managed in as careful a way, with regard to traversing the work, as was possible. In any future work no doubt the hint thus given at Prospect would not be lost sight of.

The President (Mr. A. D. Nelson) endorsed all that Mr. Salmond had said with regard to the care manifested in the construction of the dam. The prevailing opinion among many of the engineers who visited the works was that the engineer in charge was excessively careful. The bullock teams had been scientifically managed over the surface, and the workmen were carefully looked after, so that only the best material and best workmanship were employed. The prevailing opinion as to the cause of the trouble was that the water was permitted to rest upon the material too soon. The evidence was clear that the clay was not the substance it should have been. It was a matter that the Government should in any future works give their attention to.

INDEX.

INDEX.

VOL. V.

1889-1890.

A

	PAGE.
Account of Receipts and Expenditure	xxxix
Act of Incorporation	vi
Address, Presidential	1
Ahrbecker, H. V., elected Hon. Sec.	xli
Andrew, T., elected Member	xliv
Andrew, T., Donation by	xliv
Analysis of Clay, Prospect Dam	167
Annual General Meeting	xxxiii
Annual Report	xxxiii
Annual Re-union	xli
Amended Sewerage Act 1889	122
Ashcroft, G., Elected Member	xliv
Ashcroft, J. W., Elected Member	xlv
Appendix to By-laws	xxi
Appointment of Editor	xxxvii
Appointment of Librarian	xliv
Appointment of Secretary	xliv
Appointment of Auditors	xlix

B

Balance Sheet	xl
Bennett, L., Elected Member	xlvi

C

	PAGE.
Callender-Webber System of Conduits	85
Cansdell, C. S., elected Member	xliv
Chettle, W. A., elected Member	xliv
Comparison of Systems of Street Traction	88
Comparative Tests of Muntz and Delta Metals	153
Conduits for Electric Cables	80
Conductors, Electric	81
Cost of Hydro-Dynamo plant	43
Cost of Electric Lighting Circular Quay	57
Cost of Electric Lighting Cowper Wharf	57
Cost of Electric Lighting G.P.O.	58
Cost of Construction of various types of transmission	102
Council, election of	xli
Cracknell, E. W., Remarks on Sanitary Engineering	139
Crib Work	24
Cruickshank, W. D., Elected Member of Council	xli
Cruickshank, W. D., Remarks on Electric Lighting	67
Cruickshank, W. D., Remarks on Electric Traction	105
Cruickshank, W. D., Remarks on Sanitary Engineering	144
Cruickshank, W. D., Remarks on Delta Metal	156

D

Dangers arising from use of Clay in Dams	159
Damage to River Banks by Floods	22
Davies, H., Paper on Epicyclic Grab Dredge	12
Delta Metal, Paper on, by W. Reeks	146
Delta Metal, Tests of	150
Dickinson, H. E., Elected Member of Council	xli
Dickinson, H. E., Remarks on River Banks	29
Dickinson, H. E., Remarks on Electric Lighting	59
Dickinson, H. E. Remarks on Electric Traction	95
Donations to Library	xxx
Donations to Rankin Memorial	xxxvi
Donations by Mr. T. Andrew	xliv
Donations by Mr. L. Hargrave	xlix
Dredge, Priestman's Grab	15
Dredge, Triple Chain System of	14
Dredge, Double Chain System of	14

E

PAGE.
Election of Officers, and Council - - - - - xli
Electric Lighting, Van Rysselberghe's System of - - - - 30
Electric Lighting, Paper on, by C. Van de Velde - - - 30
Electric Light at Circular Quay - - - - - 57
Electric Light at Cowper's Wharf - - - - - 57
Electric Light at General Post Office - - - - 58
Electric Light at Tamworth - - - - - - 70
Electric Light at Young - - - - - - 70
Electric Traction - - - - - - - - 6
Electric Traction, Paper by G. Fischer - - - - 77
Epicyclic Grab Dredge, Paper by H. Davies - - - - 12
Excursion to Patent Asphaltum Co.'s Works - - - xxxvii
Excursion to Ryde and Chatswood Reservoirs - - - - xlvi
Experiments on Elevated Railroads - - - - 93

F

Fascines - - - - - - - - - 23
Fischer, G., Elected Vice-President - - - - xli
Fischer, G., Remarks on River Banks - - - - - 28
Fischer, G., Remarks on Electric Lighting - - - 46
Fischer, G., Remarks on Prospect Dam - - - - 175
Fischer, G., Paper on Electric Traction - - - - 17
Fire Escape, Paddle's Patent - - - - - - xlviii
Fitzmaurice, J. S., Remarks on Electric Lighting - - - 53
Fitzmaurice, J. S., Remarks on Electric Traction - - - 97
Flying Machine, L. Hargraves - - - - - xxxvii

G

General Meetings, Minutes of - - - - - xxxiii-xlii

H

Hargrave, L., Elected Member of Council - - - xli
Hargrave, L., Elected Librarian - - - - - xliv
Hargrave, L., Flying Machine - - - - - xxxvii
Hargrave, L., Donation by - - - - - - xlix
Haycroft, J. R., Elected Auditor - - - - - xlix
Haycroft, J. R., Remarks on Sanitary Engineering - - - 143
Haycroft, J. R., Remarks on Prospect Dam - - - 175
Haycroft, J. R., Remarks on River Banks - - - - 29
Henson, J. B., Elected Member of Council - - - xli

PAGE.
Henson, J. B., Remarks on River Banks - - - - 28
Henson, J. B., Remarks on Electric Traction - - - 114
Henson, J. B., Remarks on Sanitary Engineering - - - 136
Hinde, A. W. T., Remarks on Electric Light - - - 69
Howe, H. B., Remarks on Electric Traction - - - - 113
Hydro-Dynamo, Van Rysselberghe's - - - - 30

I

Incorporation, Act of - - - - - - - vii
Inspection of Land Boilers - - - - - 9
Introduction of Electric Traction in Europe - - - - 77
Introduction of Electric Traction in America - - - 78
Irrigation in America - - - - - - - 4

J

Jones, J. Trevor, Remarks on Sanitary Engineering - - 134

L

Launch of 600-Ton Barge at Atlas Engineering Co. - - - xlix
Leo. Daft, Experiment Elevated Railroads, New York - - 93
Librarian, Appointment of - - - - - - xliv
Library, Donations to - - - - - - xxx
List of Members - - - - - - - xxv
List of Papers, 1888-9 - - - - - - xxxv
Loss in various Systems of Power Transmission - - - 103
London and Southwark Subway - - - - - 108

M

Minutes of Proceedings - - - - - xxxiii-xlii
Mechanical Exhibition, Proposed - - - - - xliv
Mileage of Sydney Sewers - - - - - - 129
Motion to Reduce Number of Meetings - - - - xxxvi

N

Nelson, A. D., Elected President - - - - - xli
Nelson, A. D., Remarks on River Banks - - - - 29
Nelson, A. D., Remarks on Delta Metal - - - - 158
Nelson, A. D., Remarks on Sanitary Engineering - - 176
Nicolle, W. E. H., Appointed Secretary - - - - xliv
Nicolle, W. E. H., Remarks on River Banks - - - 28
Nixon, E. S., Elected Member - - - - - - xlvii
Nixon, E. S., Remarks on Electric Traction - - - 112

O

PAGE.
Overhead Electric Conductors - - - - - - 81

P

Paddle's Patent Fire Escape - - - - - xlviii
Papers, List of, 1888-89 - - - - - - xxxv
Patent Asphaltum Works, Visit to - - - - xxxvi
Pickering, J., Elected Member - - - - - - xlvi
" Prevention of Damage to River Banks," Paper on, by W. Seymour Wells - - - - - - - - 22
Presidential Address - - - - - - - - 1
Prospect Dam, Report on, by A. Mackay - - - - 167
Prospect Dam, Analysis of Clay in - - - - - 167
Public Health, Metropolitan, J. M. Smail - - - - 118
Pollock, R., Elected Member of Council - - - - xli
President, Election of - - - - - - xli

R

Rainfall, influence of, on Death Rate - - - - - 128
Rankin Memorial, Donation to - - - - - xxxvi
Receipts and Expenditure, Account of - - - - xxxix
Regulation of River Channels, W. S. Wells - - - 22
Report, Annual - - - - - - - xxxiii
Report on New South Wales Railways - - - - 10
Resignation of Editor - - - - - - xxxvii
Reunion, Annual - - - - - - - xli
Rock, J. W., Elected Member - - - - - xxxiii
Rules and By-laws - - - - - - xiv
Ryde and Chatswood Reservoirs, Excursion to - - - xlvi

S

Salmond, D., Elected Member - - - - - xliii
Salmond, D., Remarks on Prospect Dam - - - - 176
Sands, J., Elected Hon. Treasurer - - - - xli
Sanitary Engineering, Paper on, by J. M. Smail - - - 118
Seaver, T. W., Elected Member - - - - - xlvii
Seaver, T. W., Remarks on Prospect Dam - - - - 175
Selfe, N., Remarks on Electric Lighting - - - - 50
Shellshear, W., Elected Member of Council - - - - xli
Shellshear, W., Remarks on River Banks - - - 28
Shellshear, W., Remarks on Electric Lighting - - - 59

PAGE.
Shellshear, W., Remarks on Prospect Dam - - - 173
Speechley, W. H., Elected Member - - - - - xlvi
Smail, J. M., Sanitary Engineering and Public Health - - 118
Storer, Dr. J., Remarks on Prospect Dam - - - - 174
Storage Batteries for Tramcars - - - - - 80
Subway, London and Southwark - - - - - 108
Sydney Sewerage Act, 1853 - - - - - 120
Sydney Sewerage Act, Amended 1889 - - - - - 122
Sydney Improvement Act, 1879 - - - - - 122

T

Tamworth, Electric Light at - - - - - - 70
Test of Delta Metal, Pinion - - - - - 150
Thorpe, R. J., Elected Member - - - - - xlvii
Transformer Efficiences - - - - - - 72

V

Van Rysselberghe's System of Electric Light - - - - 30
Van de Velde, C., Paper on above - - - - 30
Vital Statistics of Sydney - - - - - - 128
Vote of Thanks to Editor - - - - - - xliv

W

Water and Sewerage Act, 1880 - - - - - 121
Water and Sewerage Act, Amended 1889 - - - 122
Wells, W. Seymour, Prevention of Damage to River Banks, Paper by 22
Westend Street Railways of Boston - - - - 91
Williamson, W. J., Elected Student - - - - - xlvii

Y

Young, Electric Light at - - - - - - 70

LIST OF ILLUSTRATIONS.

PLATE.
Electric Traction - - - - - - I to V
Davies' Patent Grab Dredger - - - - - VI-VII
Death Rate Diagram - - - - - - - VIII
Delta Metal - - - - - - - - IX
Section of Prospect Dam - - - - - - X

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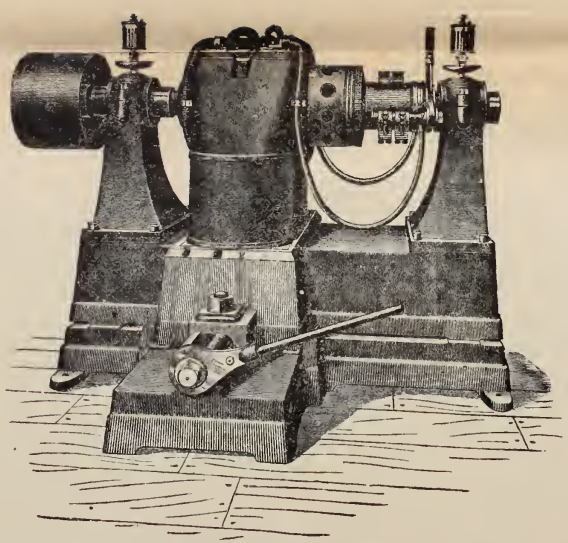
Plate I.



40,000 WATT MOTOR TYPE DYNAMO.

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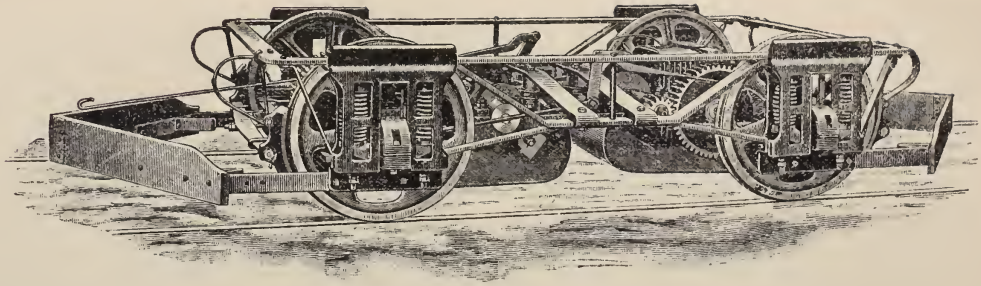

NEW TYPE THOMSON-HOUSTON ELECTRIC RAILWAY TRUCK.

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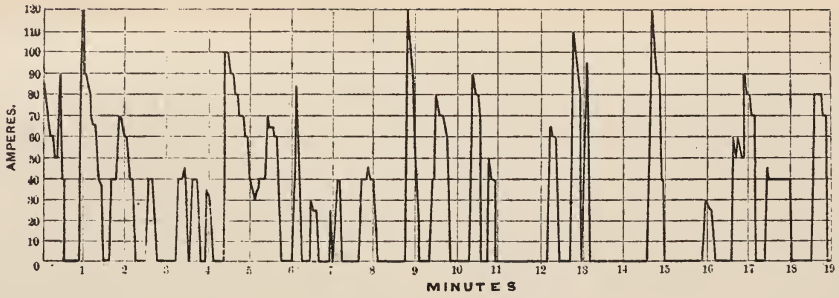
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9
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11
12
13
14
15
16
17
18
19
MINUTES

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Plate IV

ELECTRIC TRACTION

Plate V

PROCEEDINGS OF THE ENGINEERING ASSOCIATION, N.S.W. SESSION 1889-90

Plate VI.

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DAVIES' PATENT GRAB DREDGER.

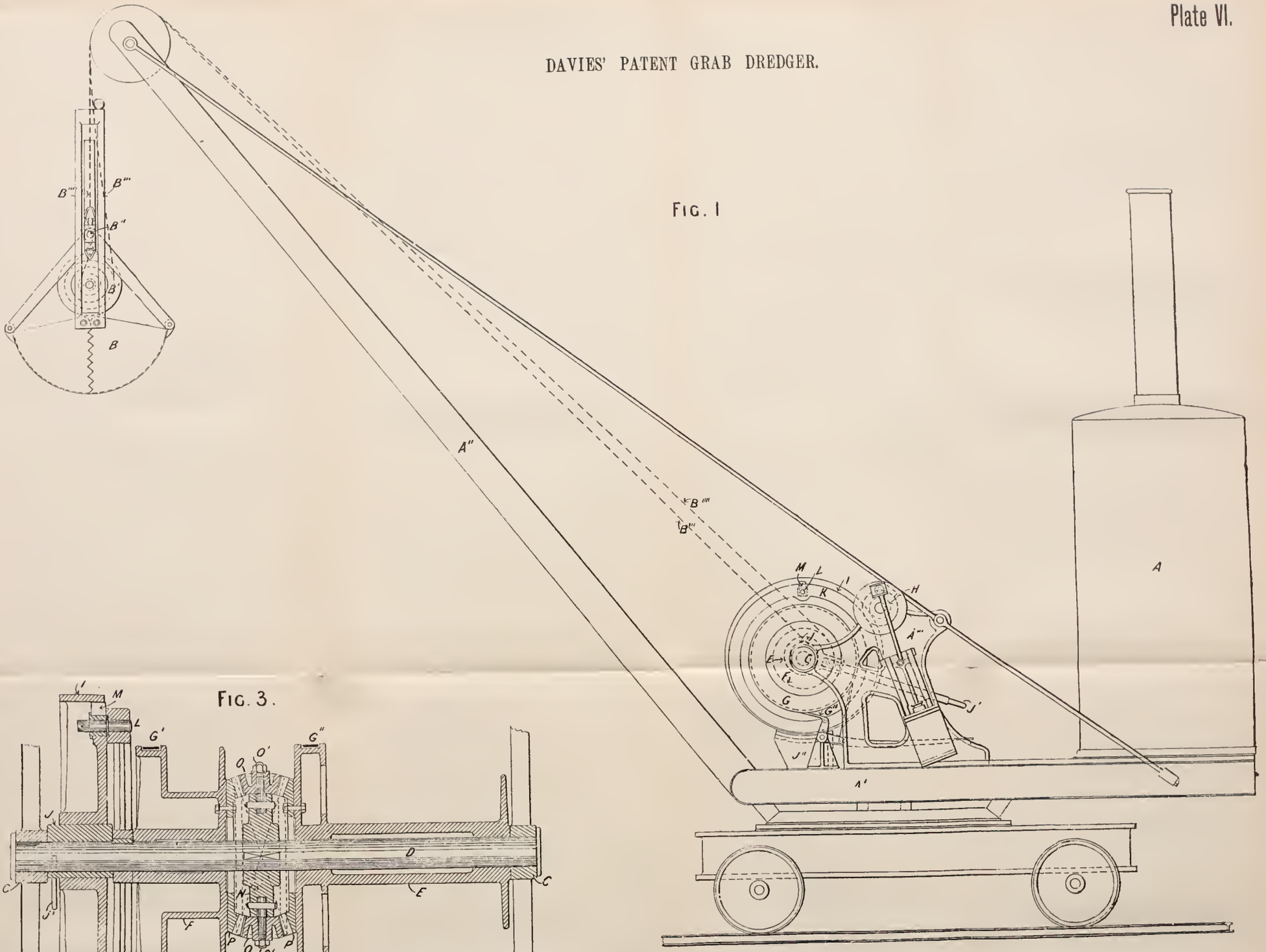
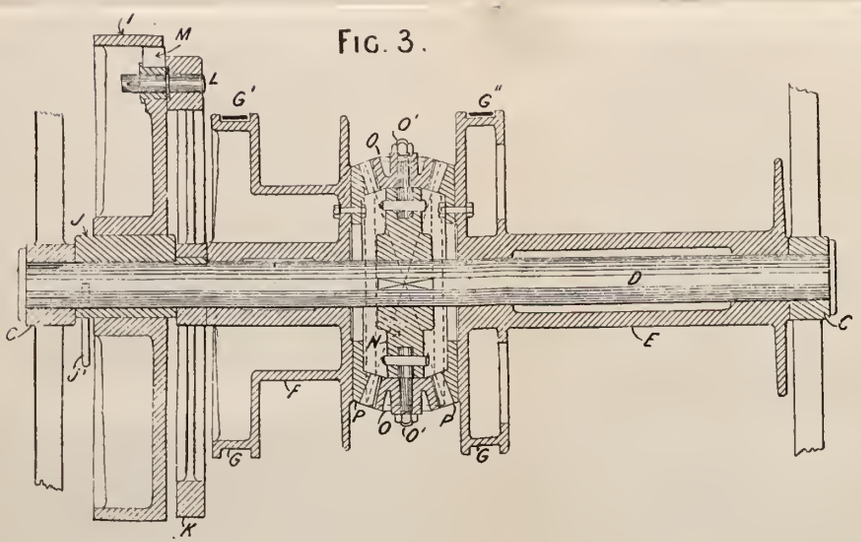


FIG. 1



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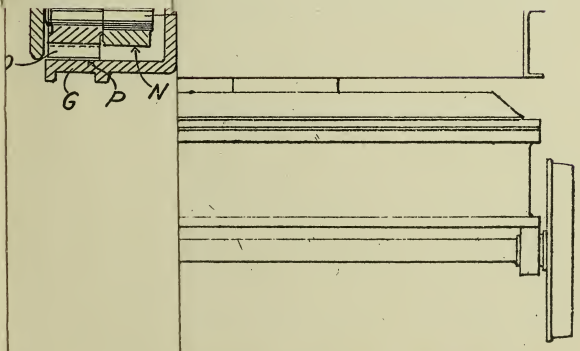


ASSOCIATION, N.S.W., SESSION 1889-90.

DAVIES' PATENT GRAB DREDGER.

Fig 4

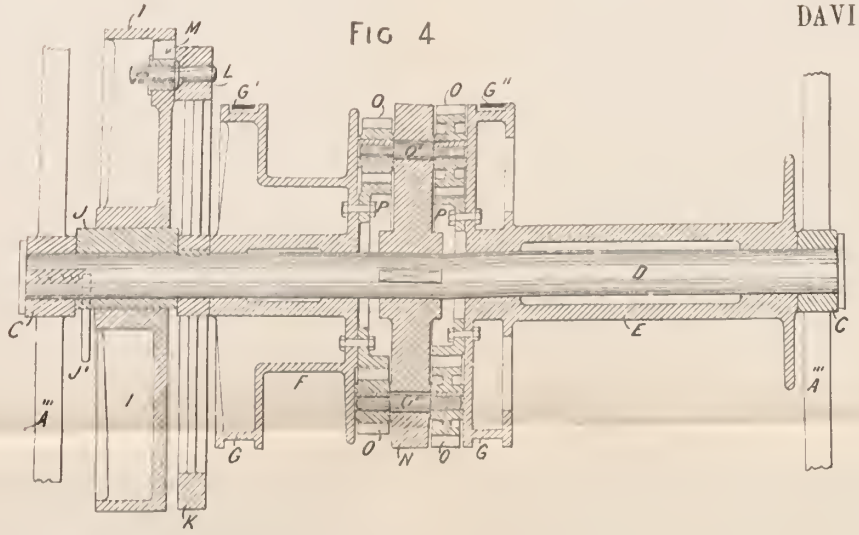
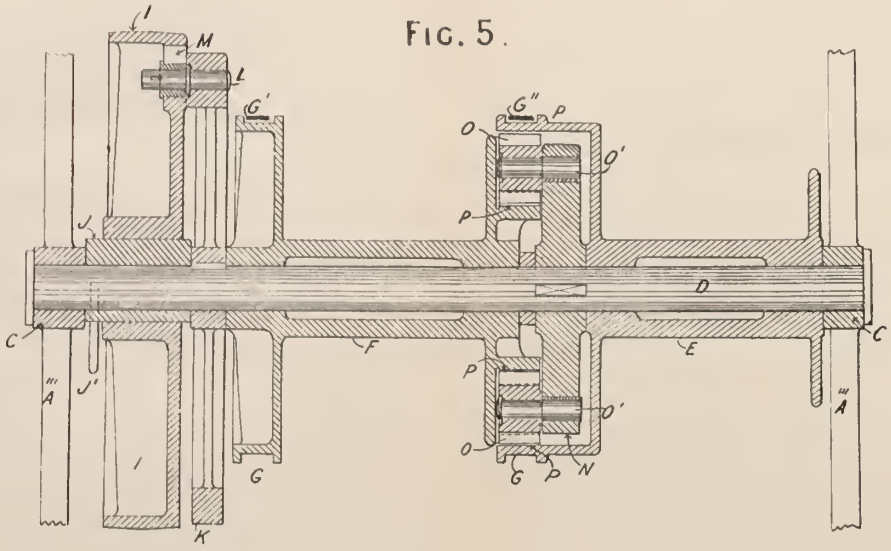


Fig. 5.



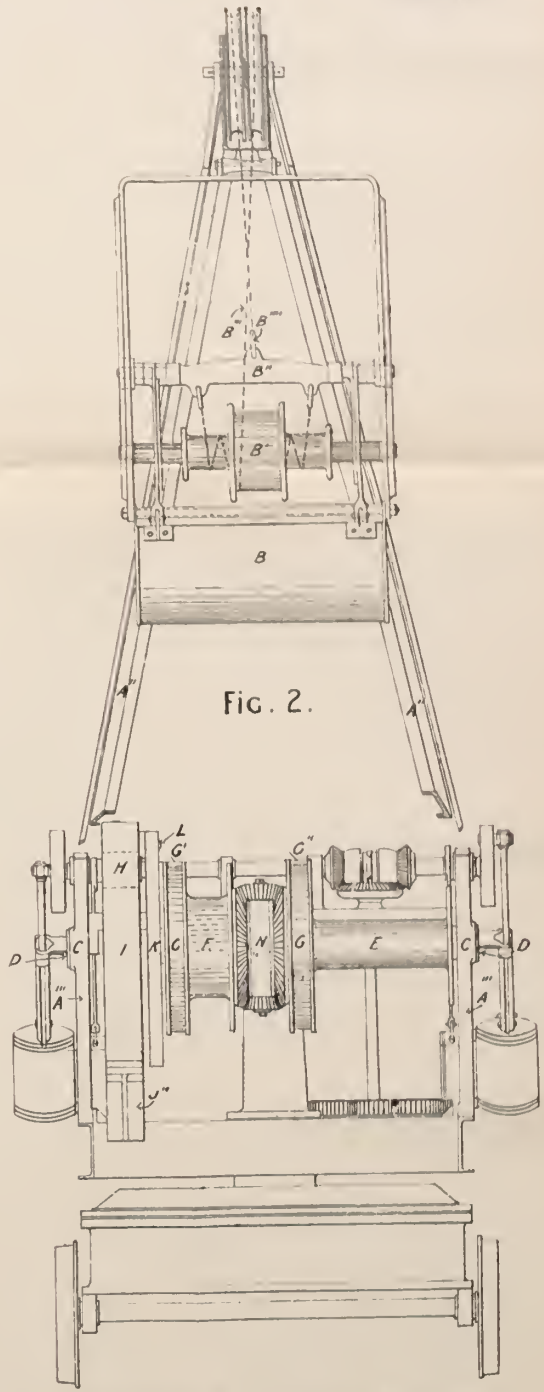


Fig. 2.

X.

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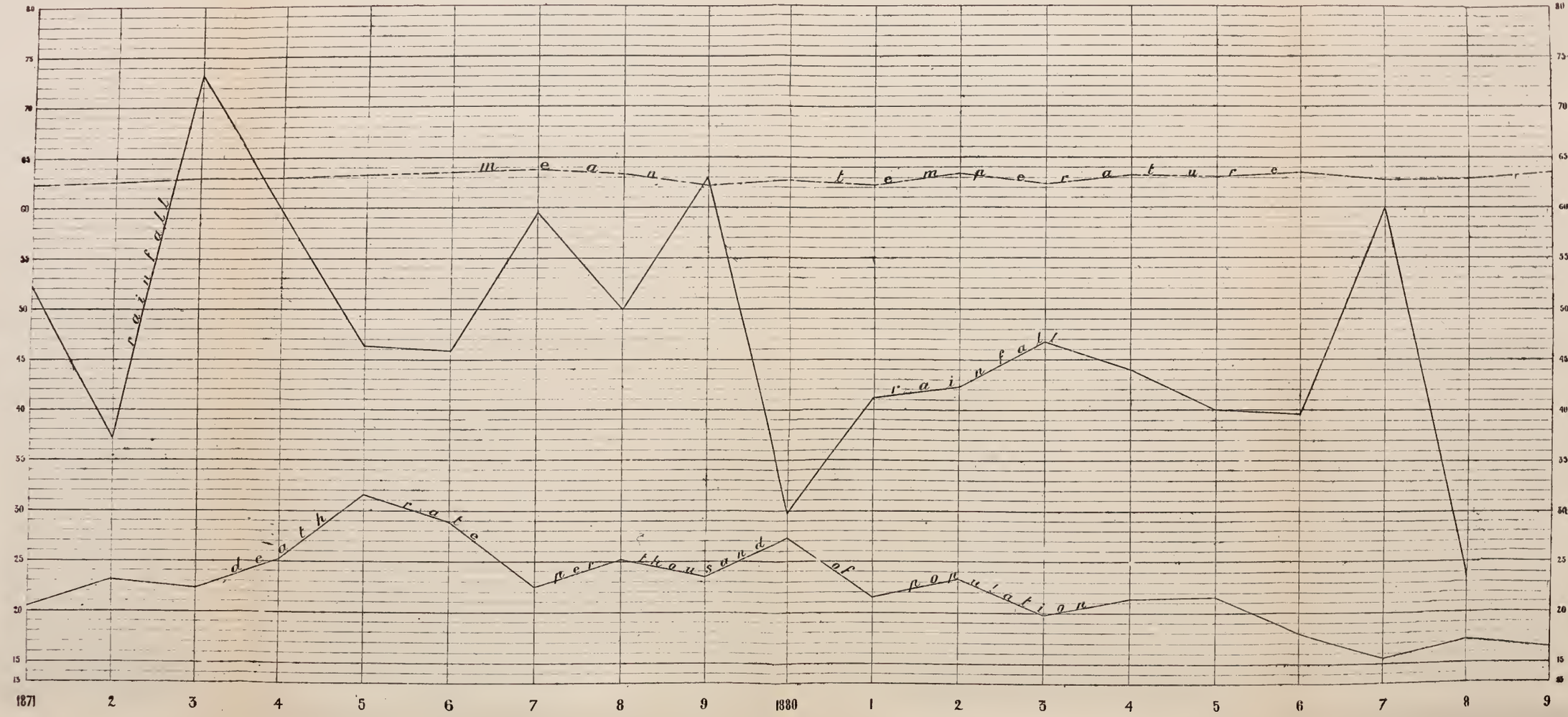
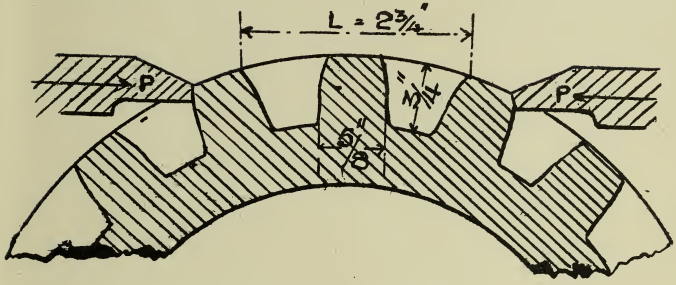
DIAGRAM

SHOWING MEAN TEMPERATURE, RAINFALL
AND DEATH RATE PER THOUSAND OF POPULATION FROM 1871 TO 1889



DELTA METAL.

Fig. 1.



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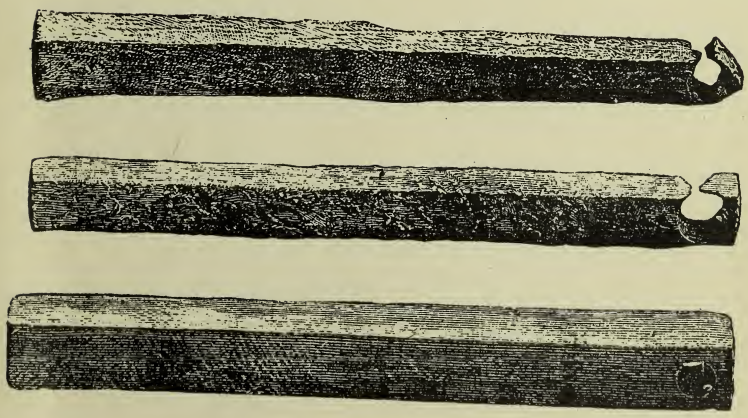

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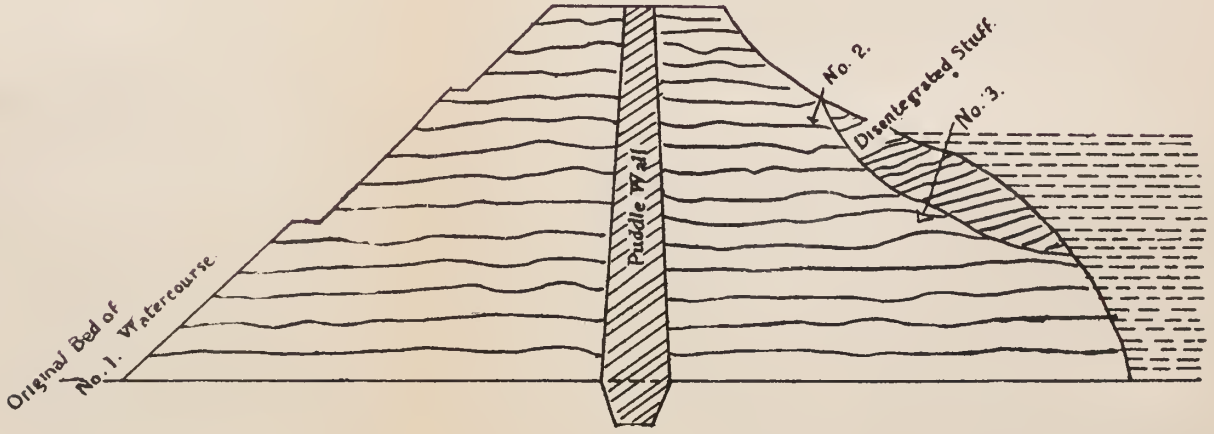

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